Guide to the Illinois Caverns State Natural Area

Samuel V. Panno, Sallie E. Greenberg, and C. Pius Weibel
Illinois State Geological Survey

Patricia K. Gillespie
Newman, Illinois

GeoScience Education Series 19

ILLINOIS STATE GEOLOGICAL SURVEY

Cover photo: A well-formed chimney in the Lunch Room, Illinois Caverns.

ILLINOIS DEPARTMENT OF NATURAL RESOURCES

ISGS Illinois State Geological Survey

Printed by authority of the State of Illinois PRT 3334711 - 5M-5/04

Printed with soybean ink on recycled paper

Guide to the
Illinois Caverns State Natural Area

Samuel V. Panno, Sallie E. Greenberg, and C. Pius Weibel
Illinois State Geological Survey

Patricia K. Gillespie
Newman, Illinois

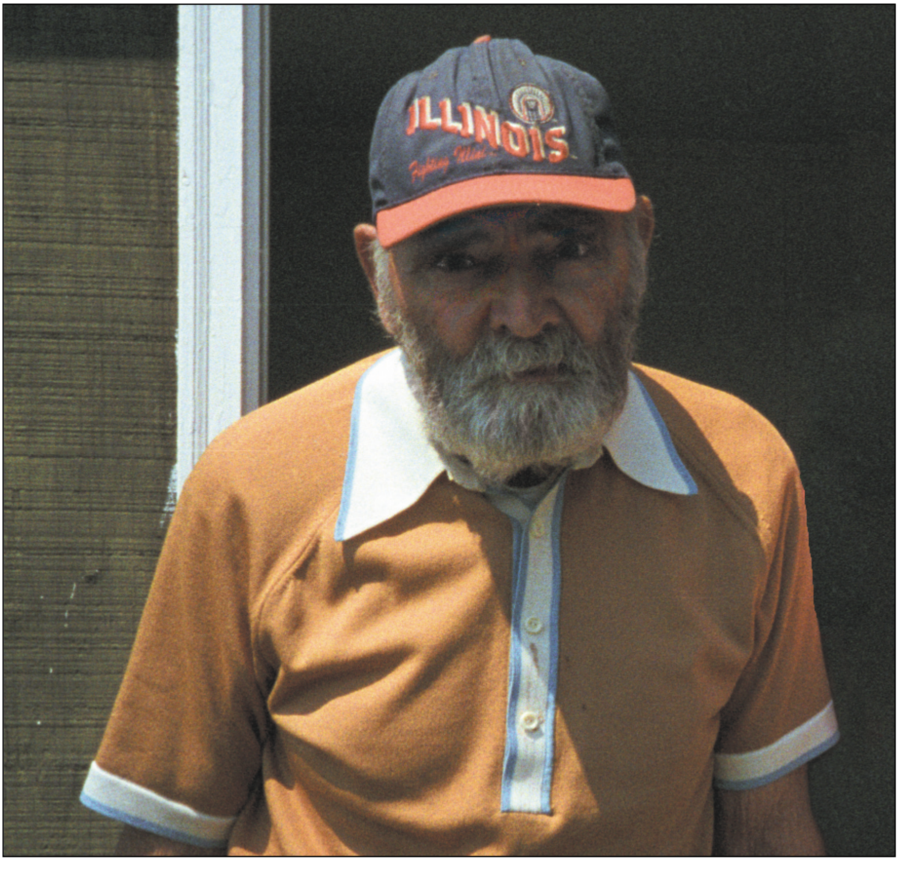
GeoScience Education Series 19

Illinois Department of Natural Resources
ILLINOIS STATE GEOLOGICAL SURVEY
William W. Shilts, Chief
615 East Peabody Drive
Champaign, IL 61820
217-333-4747
http://www.isgs.uiuc.edu

DEDICATION

This guide is dedicated to Mr. Armin Henry Krueger (1914–1996) and other environmentally active individuals for their important efforts in the preservation and protection of our natural heritage. They have drawn attention to the fragile nature of unique ecosystems and environments and have inspired others to preserve the natural areas of Illinois.

The late Mr. Krueger's work, continued efforts by others, and judicious management by the State of Illinois have helped maintain the near-pristine conditions of the Illinois Caverns State Natural Area. Continued vigilance and dedication are necessary to preserve this natural area and its unique fauna for the education and enjoyment of future generations and for continued scientific research.



Mr. Armin Henry Krueger at work at Illinois Caverns State Natural Area. Mr. Krueger was caretaker of the cave between 1951 and the time of his death (one week after this photograph was taken). He loved caving and was well known to cave visitors.

PREFACE

This guide describes, in detail, the natural features that may be observed on the sinkhole plain and found at the surface and subsurface of the Illinois Caverns State Natural Area. The significance, origin, and evolution of these features are described, and an illustrated self-guided walking tour through the cave is included.

This guide is intended to reveal the geologic and natural history of the Illinois Caverns State Natural Area and to show the effects of human activities on the cave and surrounding region. The guide was written for all interested individuals but especially for teachers of children in middle school through the first year of college. This publication and its companion documents should be useful for teachers, scout leaders, parents, and others who lead children through the dark and deep passages of Illinois Caverns.

CONTENTS

DEDICATION iii

PREFACE iv

INTRODUCTION 1

HISTORY OF THE ILLINOIS CAVERNS STATE NATURAL AREA 5

CAVE DEVELOPMENT AND THE ICE AGE 12
- Pre-Pleistocene History 12
- Pleistocene History 15
- How and When Did Illinois Caverns Form? 16

GEOLOGY OF THE ILLINOIS CAVERNS STATE NATURAL AREA 18
- Karst Terrain and Karst Regions of Illinois 18
- What Is Karst? 19
- What Are Sinkholes? 19
- What Is a Cave? 20
- Water: An Agent of Change 23
- The Hydrologic Cycle 24
- The Karst Hydrologic Cycle 25
- Water Quality 26
- The Role of Water Chemistry in Cave Formation 27
- Speleothem Formation 30

THE PLANTS AND ANIMALS OF THE ILLINOIS CAVERNS STATE NATURAL AREA 35
- Unique Natural Features and Vegetation 35
- The Barrens 35
- A Surface Tour 35
- Life in the Subsurface 43
- Endangered Species of Illinois Caverns 46
- Bats 46
- The Surface Connection 49

TOUR OF ILLINOIS CAVERNS 51
- Before You Begin Your Tour 51
- The Cave Entrance 53
- The Cave 55
- Cross-sectional Shape of Cave Passages 56
- Chert 58
- The Stream 59
- Broken Stalactites 61

Cave Vandalism	63
The First Waterfall	64
Canyon Passage	66
Scallops along the Stream Bed	68
Protocave	69
Ladders	70
Canyon Passage Stalactites	71
Giant's Foot	72
T-Junction	73
Lunch Room	74
Main Passage	76
Mushroom Passage	78
Capitol Dome	81
Cascade Canyon	84
Chimney Dome Passage	86
Rimstone River	88
Breakdown Room	89
Upper Dry Passage	90
Waterfall	92
Rock Falls	93
Potholes	94
The Dragon	95
Water Passage and Beyond	97
Dye Spring	97
ACKNOWLEDGMENTS	98
CREDITS	98
SELECTED REFERENCES AND FURTHER READING	99
GLOSSARY	103

INTRODUCTION

Thousands of visitors each year experience the wonder and beauty of the Illinois Caverns State Natural Area, by hiking its prairie trail, picnicking, and, especially, by traveling through the “wild” cave that lies beneath the surface. Unaltered by the underground pavement or artificial lighting systems of some larger caves, Illinois Caverns provides the opportunity for modern adventurers to explore its passageways in a more natural setting and see its features in a manner not very different from that of previous generations. With about 6 miles of mapped passages, Illinois Caverns is one of the most spectacular of these caves and among the longest in the state.

Illinois Caverns and the land surrounding its entrance are nested in the heart of Illinois’ sinkhole plain, located in Monroe County in southwestern Illinois (figs. 1 and 2). This area’s classic karst terrain is a landscape containing many sinkholes, large springs, and caves. Areas such as this one have played a significant role in the evolution and history of humankind and the scientific understanding of the planet’s physical environment. Although first used as shelters as early as 700,000 years ago, evidence from

Figure 1 Aerial view of Illinois’ sinkhole plain. Sinkhole density in this area is about 230 sinkholes per square mile. Sinkholes appear as circular ponds, circular clumps of trees, and more subtle indentations in the landscape.

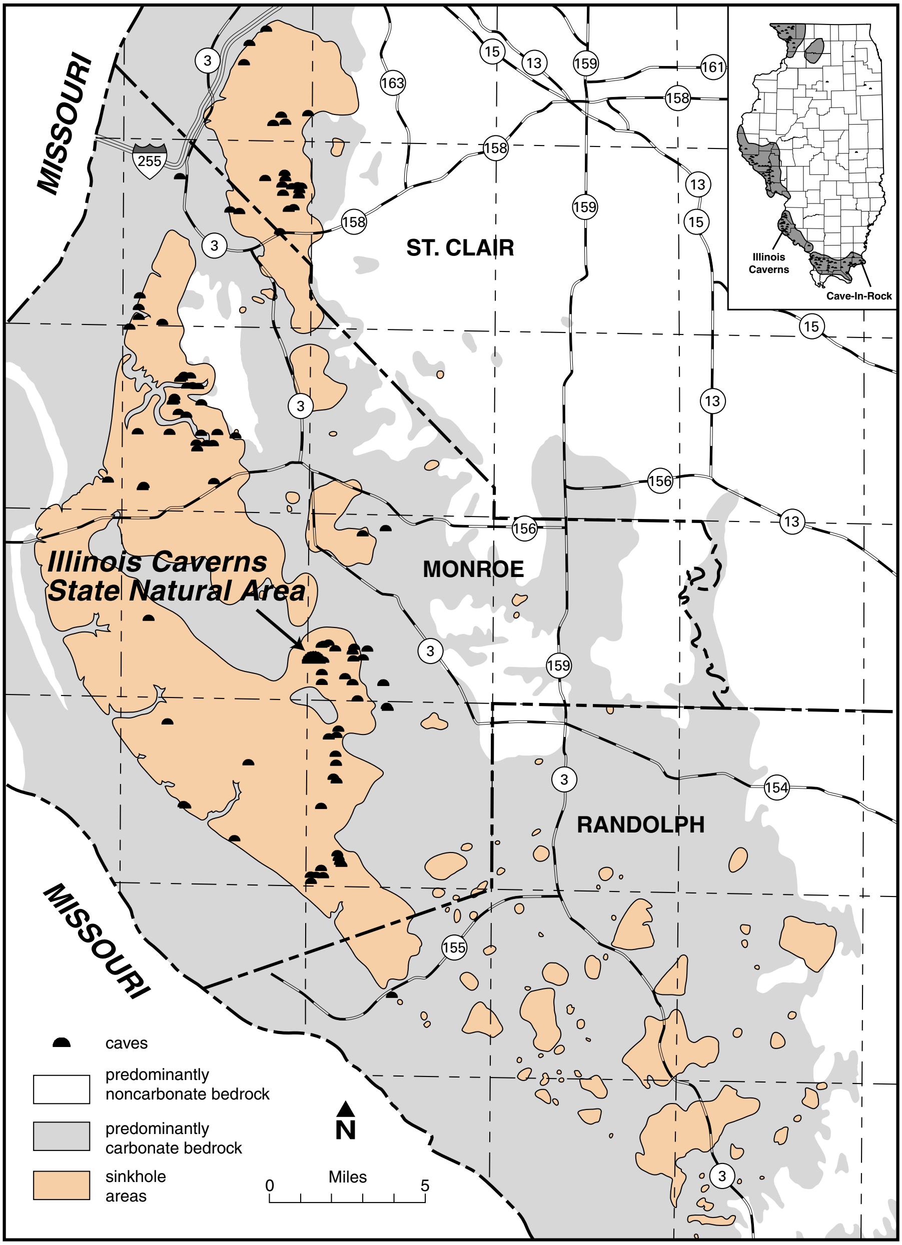


Figure 2 Illinois Caverns is one of many caves located in the karst terrain of Illinois' sinkhole plain. Sinkholes occur in thick loess, a fine silt, and glacial sediments (clay, silt, and sand) that cover the carbonate bedrock (predominantly limestone) on the uplands of southwestern Illinois.

Figure 3 Limestone was commonly used in southwestern Illinois for constructing bridges, buildings, houses, wells, and other structures. Masons built arched bridges throughout the area using stone they quarried themselves from nearby sources. Fountain Creek Bridge (top) was the first stone bridge built in Monroe County. The now-abandoned building at Valmeyer Quarry (bottom) was constructed when the quarry was started in the early 1900s. The building appears to have housed an office and a shop.

as early as 32,000 years ago shows that caves also were used for storage, religious rituals, and burials and served as a place of communication and artistic expression (cave paintings).

Early European settlers to the Illinois-Missouri-Kentucky region used caves in many ways. For example, they mined saltpeter (potassium nitrate), a key ingredient of gunpowder, from Kentucky's Mammoth Cave sediments during the War of 1812. Later in the nineteenth century, parts of Mammoth Cave were used as a tuberculosis sanitarium. The numerous caves beneath the streets of St. Louis, Missouri, were used by brewers and winemakers for cool-temperature storage and by others as entertainment centers, theaters, and swimming pools. During the Civil War, caves were used as secret meeting places and for arms and ammunition storage. Bootleggers used caves as clandestine storage areas during Prohibition in the early twentieth century. The limestone in the area surrounding the caves was used locally to construct bridges, buildings, and other structures (fig. 3).

Today, caves are used primarily for recreation and tourism. Many large caves have been commercialized or made part of state or national parks. Private citizens and scientists, many of whom are affiliated with the National Speleological Society, are still finding and exploring large caves in the United States and other countries. Members of the National Speleological Society are active in the protection and preservation of caves and their fauna throughout the world. Currently, scientists are studying caves for clues to climatic changes that occurred over the past million years and to discover and understand the cave's exotic bacteria and other fauna.

HISTORY OF THE ILLINOIS CAVERNS STATE NATURAL AREA

Southwestern Illinois was inhabited by Native Americans, including the builders of Cahokia Mounds, for thousands of years prior to the arrival of Europeans in the late seventeenth century. French explorers were followed by the English, Irish, Scottish, and Welsh, who eventually came to rule and own the land. The first town near the cave was Bellefontaine (French for "beautiful spring"), originally a trading post and a stopover for western expeditions, including the Lewis and Clark expedition of 1803. The spring and remaining buildings are now a historic site (figs. 4, 5, and 6). During the early nineteenth century, German immigrants to the area were often paid in land for their work. Eventually, because of this practice, the Germans came to own most of the land, and their descendants now farm it. Agriculture is the region's main industry, and about 70% of the area is cultivated.

Although the cave at Illinois Caverns State Natural Area was known to exist, no evidence of its exploration by Native Americans or European settlers has been documented prior to exploration by the landowners in the early nineteenth century. The cave was originally named Burksville Cave,

Figure 4 The spring at Bellefontaine is a small, clear pool of water that issues from the bedrock. The spring is typical of those in a karst region; once 3 or more feet deep, the spring is now fairly shallow after years of sedimentation.

then Mammoth Cave of Illinois, and finally Illinois Caverns. Early explorers used ladders and possibly ropes to descend to the entrance, which is located at the bottom of a sinkhole. From the top of the sinkhole, a negotiable, wooded slope descends steeply about 60 feet. At the bottom of the slope, there is a large crevice with an abrupt vertical drop of about 30 feet to the cave floor.

Illinois Caverns made front-page news in the *St. Louis Post-Dispatch* on February 17, 1901 (fig. 7). The article stated that the cave had been known to exist since about 1800, but had remained unexplored until 1883, when John Helber and William Heining of Red Bud were the first to map the cave. In their excitement, these early explorers overestimated the length of the cave and suggested that its length could exceed that of Mammoth Cave

Figure 5 A plaque on a limestone block on the north side of Road KK, just north of Illinois Caverns, commemorates the location of the first English-speaking public school in Illinois. The school was started in 1783 in an abandoned squatter's cabin.

Figure 6 Log cabins, still found throughout the sinkhole plain, were the first homes built in the area when it was being settled. This cabin was built by German immigrant Johann Georg Stemler in 1836 and is located in St. Clair County. The Stemlers settled on property that had a cave (Stemler Cave) for cool storage of eggs and milk.

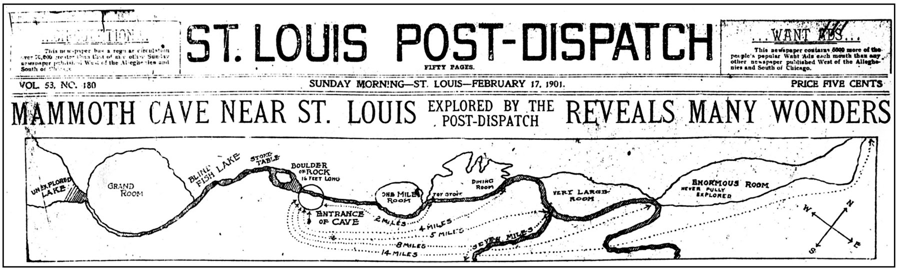


Figure 7 An early map of Illinois Caverns was prepared by William Heining in about 1883. Rooms were named by John Helber (*St. Louis Post-Dispatch,* February 17, 1901).

in Kentucky. The explorers were guided by landowner Frederick Eckert and his son Henry. The party, carrying torches and lanterns, descended into the sinkhole on a series of two oak ladders. The relatively dim light of the torches and lanterns did not allow the party to see the ceiling or walls in many parts of the cave, causing it to appear much larger than it actually was. During their visit, the early explorers found it necessary, in places, to extend the lantern ahead of them on a pole to keep from falling over waterfalls they could hear but had trouble seeing. ***Stalactites,*** located in a room just a "bow shot" from Cascade Canyon, were reported to glisten like stars under lantern light, and the early visitors named the room "Star Chamber." During this exploration, rooms were described as being so large that "a street car line and four carriages driven abreast would have found abundant room in this gigantic passage."

Following these explorations, several attempts were made to develop Illinois Caverns as a tourist attraction. Initially, the landowner, Frederick Eckert, leased the cave to a Mr. White from East St. Louis as a sightseeing attraction that drew its first visitors on April 23, 1901. For those visiting from distant locations, transportation to the cave was by train to Burksville Station and then by horse-drawn wagon to the cave entrance several miles to the southwest. At that time, passages were lit with wall-mounted kerosene lamps for the tours.

Additional exploration was sparked by the notion that the cave could be a "great natural attraction" for the 1904 World's Fair that was to be held in St. Louis, Missouri. Some of the descriptions hint at the changes that have taken place over the years of visitation by the public. For example, part of the cave stream was described as "teeming with blind eyeless fish"; fish are only occasionally seen in the cave today. The early tourists were not immune to the temptation to collect souvenirs. The reporter noted that, “At the end a chamber of white stalactites extending from either side of the room tempts the eye. Fragile as they seem, it takes a hard knock to dislodge fragments.”

Illinois Caverns was indeed a popular attraction during the 1904 World’s Fair, when the number of visitors reached an all-time high. President Theodore Roosevelt is reported to have visited the cave during the fair, and he is alleged to have signed the visitors’ book (fig. 8), although this claim has not been substantiated. Records of Theodore Roosevelt’s activities, however, indicate that he didn’t attend the World’s Fair until late November 1904 (about two months after the signature appeared). After the World’s Fair, business dropped dramatically, and the enterprise ended in 1907.

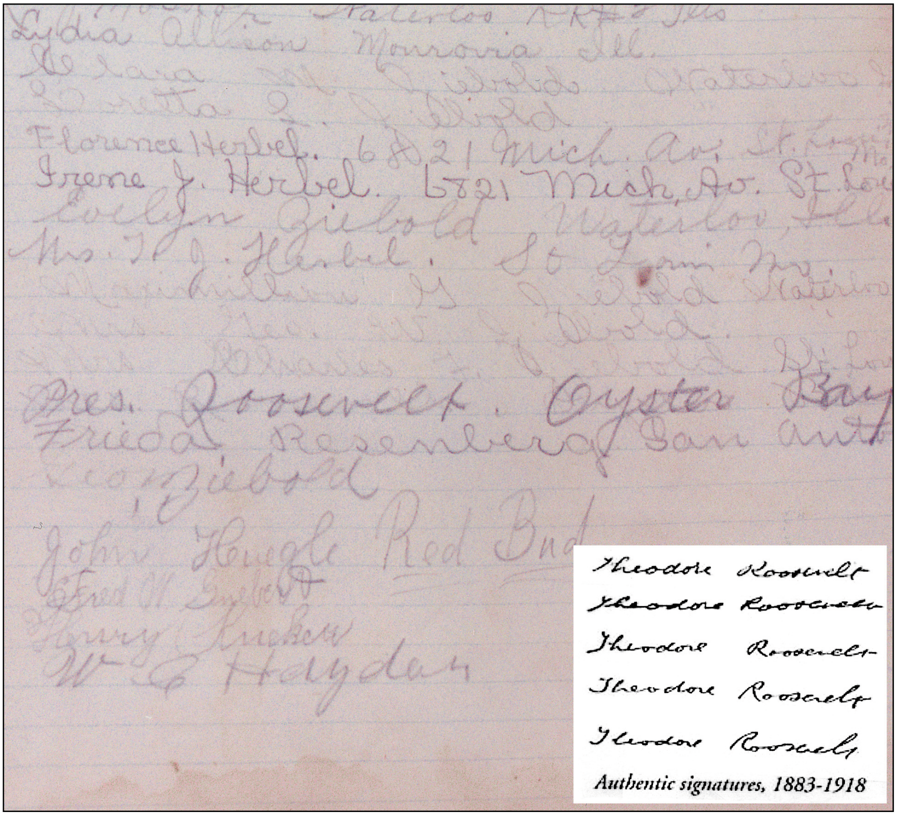


Figure 8 President Theodore Roosevelt reportedly visited Illinois Caverns on September 18, 1904, during the St. Louis World’s Fair. An unsubstantiated signature of his appeared in the cave visitor’s book. Actual signatures of the president are in the lower right-hand corner for comparison. Notice that the first signature has been overwritten by someone using a darker pen.

William Hayden purchased the Eckert farm in 1947, and he and his nephew, Robert Hayden, again attempted to commercialize the cave (fig. 9). Electric lights were added to the passages. (The hooks that held these lights are still present in some of the passages.) However, visitation was disappointingly small, and, as before, the business quickly ended.

During the late 1940s or early 1950s, Armin Krueger, who was born nearby in 1914, became caretaker of the cave. He guided countless visitors through Illinois Caverns and other caves in the region. Robert Hayden sold the cave to the State of Illinois in 1985, and Krueger continued as caretaker, becoming a legendary figure among the many cave visitors and National Speleological Society caving groups that frequented Illinois Caverns. He also occasionally assisted another avid caver and Catholic priest, Father Paul Wightman (fig. 10), in exploring caves and using water-soluble dyes

Figure 9 Early, weathered signs for Illinois Caverns, used by the Haydens in the late 1940s and 1950s. The larger sign states “ILLINOIS CAVERNS, Picnic Areas, Bar B Q Pits, NATURE AT WORK, Great Scenic Wonder, See it All, ATOMIC SHELTER.” The smaller sign states “SLOW 5 MPH, Adm. $1.50, Visit Gold Room, See Captl Dome, Private Prop.”

Figure 10 Father Paul Wightman, shown here in Fogelpole Cave in 1999, was a pioneer in the exploration, mapping, and dye-tracing of caves in the sinkhole plain from the 1940s through the 1960s.

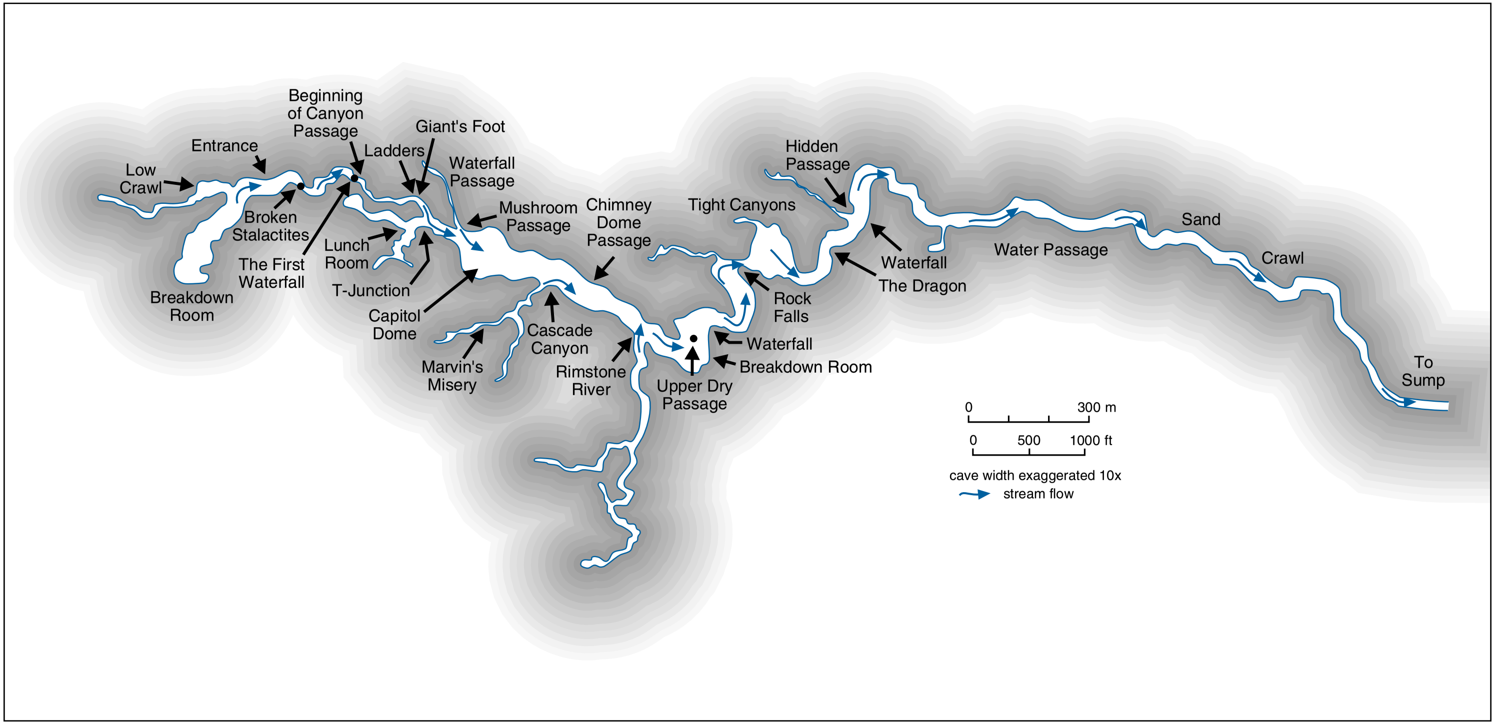


Figure 11 The latest map of Illinois Caverns, modified from the 1996 Illinois Department of Natural Resources map, shows the locations of various features discussed in the tour section of this document. The widths of the passages have been exaggerated by a factor of 10 by the authors to give a better representation of the cave. The cave contains about 6 miles of mapped passage, most of which is shown here.

to trace the flow and discharge of cave water from nearby springs. Father Wightman was a pioneer in cave exploration, mapping, and determining which springs were fed by which caves in the sinkhole plain. Krueger continued to greet visitors and occasionally led tours through this and other caves in the area until two days before his death on August 22, 1996.

The cave is now monitored and maintained by a full-time site interpreter employed by the State of Illinois. Over 6,000 visitors come to the cave each year. The latest map of Illinois Caverns (fig. 11), featured in the state's brochure of the cave, was first prepared by the Windy City Grotto of the National Speleological Society in 1979.

CAVE DEVELOPMENT AND THE ICE AGE

Pre-Pleistocene History

Long before its human history, the geologic history of Illinois Caverns began: 354 to 323 million years ago during the Mississippian Period when a rock unit named the St. Louis Limestone was deposited. Illinois at that time was a very different place. The land mass lay about 25 degrees south of the equator and was submerged in a shallow sea that covered much of the continent (fig. 12). The climate was tropical, and the nearest shoreline was to the west where the Ozark Dome remained above sea level. In contrast, today the Illinois Caverns State Natural Area is located about 39 degrees north of the equator, and the climate is mildly temperate and seasonal.

The St. Louis Limestone provides rock and ***fossil*** evidence that the ocean environment varied over time as the sea level periodically rose and fell. The sea level changes resulted in different environments in which unique plant and animal communities thrived.

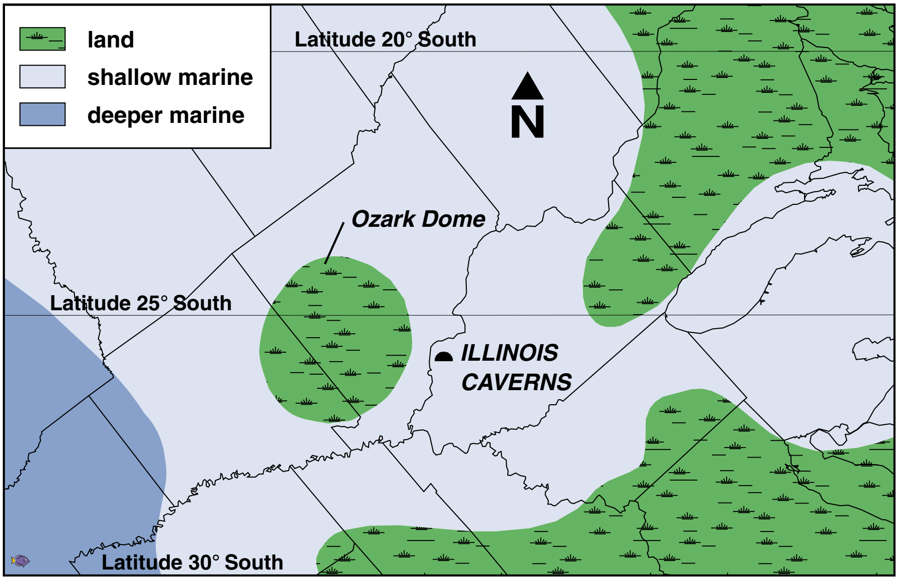


Figure 12 Regional paleogeographic map of Illinois and Illinois Caverns area during the Mississippian age. At that time, the future site of Illinois Caverns was located about 25 degrees south latitude.

Many marine animals thrived in the open shallow marine environments present throughout most of the region at times during the Mississippian Period. Open marine conditions typically occurred offshore in waters with normal ranges of salinity. Fossil evidence found in the rocks shows ***brachiopods, echinoderms, gastropods, bryozoans,*** and solitary corals living then (fig. 13). Colonial corals and cephalopods were less common. A modern example of an open marine environment is Florida Bay or the Bahamian Islands, where calcium carbonate-rich muds are deposited in relatively shallow water depths.

A restricted marine environment is characterized by shoreline and tidal flat deposits, such as that found today along the shore of the Persian Gulf. In a restricted marine environment, water fluctuates rapidly from very salty to normal marine salinity to brackish, depending on the sea level and climatic conditions. As a result, the fossils are quite different from those found in an open marine environment. Fossils in the nearshore restricted marine deposits mostly consist of microscopic ***foraminifera*** and ***ostracodes,*** small gastropods, and algae.

Figure 13 Mississippian age horn coral (*Neozaphrentis* sp.) can be seen in some places on the ceiling of Illinois Caverns. The coral fossil is evidence that the limestone is of marine origin and serves as an indicator of the limestone's relative age.

Era		Period or System and Thickness	Epoch	Age (years ago)	General Types of Rocks
CENOZOIC "Recent Life"	Age of Mammals	Quaternary 0–500′	Holocene	10,000	Recent; alluvium in river valleys
			Pleistocene Glacial Age	1.8 m	Glacial till, glacial outwash, gravel, sand, silt, lake deposits of clay and silt; wind deposits of loess and sand dunes. Deposits cover nearly all of state except northwest corner and southern tip
		Tertiary 0–500′	Pliocene	5.3 m – 33.7 m	Chert gravel, present in northern, southern, and western Illinois
			Eocene	54.8 m	Mostly micaceous sand with some silt and clay; present only in southern Illinois
			Paleocene	65 m	Mostly clay, little sand; present only in southern Illinois
MESOZOIC "Middle Life"	Age of Reptiles	Cretaceous 0–300′		144 m – 290 m	Mostly sand, some thin beds of clay, and, locally, gravel; present only in southern and western Illinois
PALEOZOIC "Ancient Life"	Age of Amphibians and Early Plants	Pennsylvanian 0–3,000′ ("Coal Measures")		323 m	Largely shale and sandstone with beds of coal, limestone, and clay
		Mississippian 0–3,500′		354 m	Black and gray shale at base, middle zone of thick limestone that grades to siltstone chert, and shale; upper zone of interbedded sandstone, shale, and limestone
	Age of Fishes	Devonian 0–1,500′		417 m	Thick limestone, minor sandstones, and shales; largely chert and cherty limestone in southern Illinois; black shale at top
	Age of Invertebrates	Silurian 0–1,000′		443 m	Principally dolomite and limestone
		Ordovician 500–2,000′		490 m	Largely dolomite and limestone but contains sandstone, shale, and siltstone formations
		Cambrian 1,500–3,000′		543 m	Chiefly sandstones with some dolomite and shale; exposed only in small areas in north-central Illinois
		Precambrian			Igneous and metamorphic rocks; known in Illinois only from deep wells

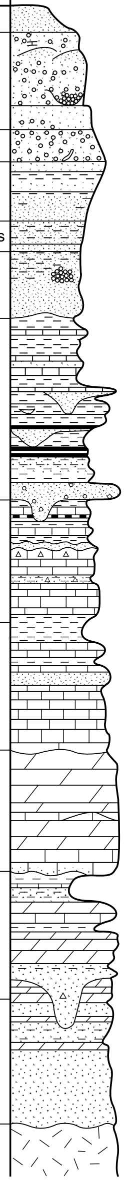


Figure 14 Geologic time scale showing the various geologic time periods and the succession of rocks in Illinois. Age is millions (m) of years ago.

Illinois rock records a major fall in sea level at the end of the Mississippian Period and the beginning of the Pennsylvanian Period (323 to 290 million years ago) (fig. 14). Mississippian age rocks were mostly deposited in marine environments, and the Pennsylvanian age rocks in Illinois are dominated by terrestrial (land-based) strata. The Pennsylvanian strata contain coal—a major Illinois resource. At Illinois Caverns, Late Mississippian and Pennsylvanian rocks have been removed by erosion, although these rocks occur a short distance to the east.

During the Late Mississippian and Pennsylvanian Periods, the rocks were deformed by lateral compression, which resulted in the tilting and bending of the bedrock strata. These folded rocks influenced the general orientation of the main conduit of Illinois Caverns and of other caves in the area and probably also were responsible for the extensive ***joints*** in the bedrock.

Pleistocene History

During the Pleistocene Epoch, also commonly known as the Ice Age (approximately from 1.8 million to 10,000 years ago), continental glaciers originating from northern Canada advanced and retreated several times across the northern continental United States, including most of Illinois. During that time, the climate was cooler, particularly during the summer, and the landscape and the plant and animal life were substantially different from those of today (fig. 16). The glaciers, which may have been about 1,000 feet thick at the latitude of the sinkhole plain, both eroded the preexisting landscape and deposited extensive layers of mostly till, but also gravel, sand, silt, and clay. As the glaciers melted and retreated, meltwaters carried these materials down the Mississippi, Missouri, and Illinois River valleys.

After these materials were deposited in the river valleys, prevailing westerly winds picked up the finer sediments and deposited them in blanket-like deposits that covered most of the state. These deposits of wind-blown silt are known as loess. The next-to-last glaciation, the Illinois Episode (300,000 to 130,000 years ago), covered most of Illinois, including the Illinois Caverns area. The last glaciation, the Wisconsin Episode (75,000 to 10,000 years ago), did not reach southwestern Illinois, but associated loess deposits of this episode did blanket the Illinois Caverns area. The thickness of till, loess, and modern deposits (collectively known as glacial drift) is typically less than 25 feet in the uplands of the Illinois Caverns area.

Figure 16 Fossil evidence indicates that very large animals such as wooly mammoths, mastodons, and peccaries roamed the sinkhole plain during the Pleistocene Epoch. Shown is an early stage of the excavation of a wooly mammoth found buried beneath Principia College near Elsah. A portion of the mammoth's tusks and skull is visible.

How and When Did Illinois Caverns Form?

The formation of the spoon-shaped depression known as the Illinois Basin during the Permian and the subsequent erosion of overlying rock brought the Mississippian age limestone to the surface in southwestern Illinois. During the course of this and subsequent movement, the bedrock in this area was fractured, and the ***bedding planes*** were slightly separated, allowing water to move through ***soluble*** limestone bedrock.

Over tens to hundreds of thousands of years, the flow of acidic water along fractures and bedding planes dissolved the bedrock and led to the formation of nearly vertical crevices up to several inches wide and small conduits along bedding planes up to 3 or 4 inches in diameter known as ***anastamoses***. As ***groundwater*** continued to flow along the bedding planes, it dissolved the limestone and enlarged the anastamoses, which became a template—or floor plan—for today's passages of Illinois Caverns. That is why the passages of Illinois Caverns, if they could be observed from above in ***plan view,*** are generally sinuous or meandering (fig. 11). Possible remnants of these early conduits or ***protocaves*** are still visible in the ceiling in some parts of Illinois Caverns (fig. 17) and other caves in the region.

The largest caves of the sinkhole plain began to form 150,000 to 125,000 years ago when ice from the Illinois Episode, which covered much of Illinois, began to melt and recede. The glacier was about 500 feet thick in the area of Illinois Caverns and provided great amounts of ice water as it melted. This cold water held more dissolved carbon dioxide than warm water could have and dissolved limestone faster. As a result, Illinois Caverns and other caves in the area began to form rapidly as the overlying glacier melted.

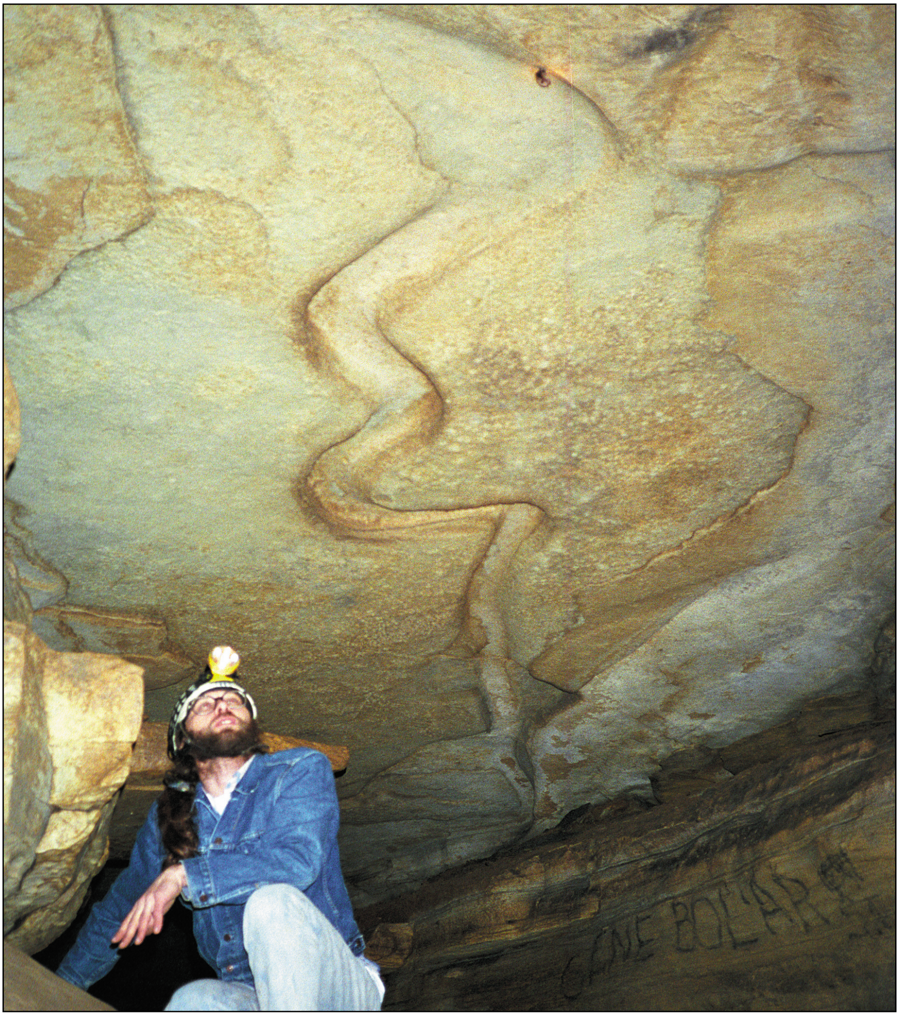


Figure 17 The upper half of one of the original conduits that was the beginning of Illinois Caverns is visible in the Canyon Passage. This protocave was originally an anastamosis about 4 inches in diameter. The protocave can be examined closely in the upper passage of the Ladders.

GEOLOGY OF THE ILLINOIS CAVERNS STATE NATURAL AREA

Karst Terrain and Karst Regions of Illinois

Approximately 25% of the bedrock surface area in Illinois is ***carbonate rock***, and about 9% of the state contains karst landforms (fig. 2, inset), the most common of these being sinkholes (fig. 18). Illinois Caverns is located in the most intensely karstified part of the state—known as the sinkhole plain (figs. 1 and 2). The sinkhole plain covers parts of St. Clair, Monroe, and Randolph Counties, and approximately 10,000 sinkholes pockmark its surface. Over three quarters of all the sinkholes in this area and some of the longest caves in the state are located in Monroe County where there are as many as 230 sinkholes per square mile. Most of the sinkholes and

Figure 18 Sinkholes are typically circular and steep-sided prior to erosion (top) and bowl-shaped after erosion. If the underlying conduit is plugged with sediment, they can hold water and become a sinkhole pond (bottom).

caves (including Illinois Caverns) occur in limestone laid down during the Mississippian Period (354 to 323 million years ago). This bedrock is made up of a thick and particularly pure deposit of calcium carbonate known as the St. Louis Limestone. Mammoth Cave in Kentucky formed in similar rock units.

What Is Karst?

Karst is a distinctive landscape constituting about 12% of the Earth's exposed land surface. Karst terrain contains landforms such as sinkholes, caves, and large springs that are shaped primarily by acidic water dissolving limestone or other carbonate bedrock and the associated collapse of the covering soil.

The geologic process of karst formation begins with water. Rain or snow falling through the atmosphere picks up carbon dioxide, which becomes dissolved in the water. As the rainwater or snowmelt reaches the land surface and percolates down through the soil, the water becomes further enriched with carbon dioxide, forming a weak solution of carbonic acid. This mildly acidic water continues to flow down into the limestone bedrock, commonly through pre-existing fractures and horizontally along bedding planes. Over long periods (thousands to hundreds of thousands of years) and with a continuous supply of carbon dioxide-enriched water, limestone bedrock slowly dissolves along fractures and bedding planes to form a more open system of water-filled fissures and conduits, known as a karst ***aquifer.*** Caves and large springs are typical of a fairly mature karst aquifer system (figs. 19 and 20).

What Are Sinkholes?

Sinkholes are topographic depressions formed in the thick soil overlying the bedrock of the sinkhole plain. These circular to elliptical features form when crevices and cavities in the bedrock are enlarged by ***dissolution.*** As a crevice enlarges, the soil (fig. 21) collapses into the crevice (from the bottom up) to be carried away by flowing groundwater. A silo-shaped cavity forms underground in the soil as the cavity works its way to the surface over the course of hours, days, or months. When the cavity approaches the surface, the surface materials collapse into the cavity, creating a sinkhole that appears—from the perspective of the viewer—to have formed instantly. The initial sinkhole has nearly vertical sides that rapidly erode from rainfall and drainage. Soon the sinkhole becomes a bowl-shaped depression that acts as a small basin for funneling surface water into the karst aquifer. Newly formed sinkholes are extremely dangerous because their walls are very unstable. The unwary explorer can be buried beneath tons of soil in seconds.

What Is a Cave?

A cave is a naturally occurring cavity in rock that is large enough for a person to enter and travel far enough from the entrance to experience total darkness. Caves are an important part of the karst hydrologic cycle and provide subsurface pathways that drain the land of rainfall and snowmelt. Despite their large size, however, caves are generally a fairly small part of the larger fissure and conduit system that makes up the karst aquifer. Groundwater flows to and through this system until it is discharged at the surface in a spring or in a low-lying area, such as a river valley. The water then enters surface streams where it flows to lakes and seas.

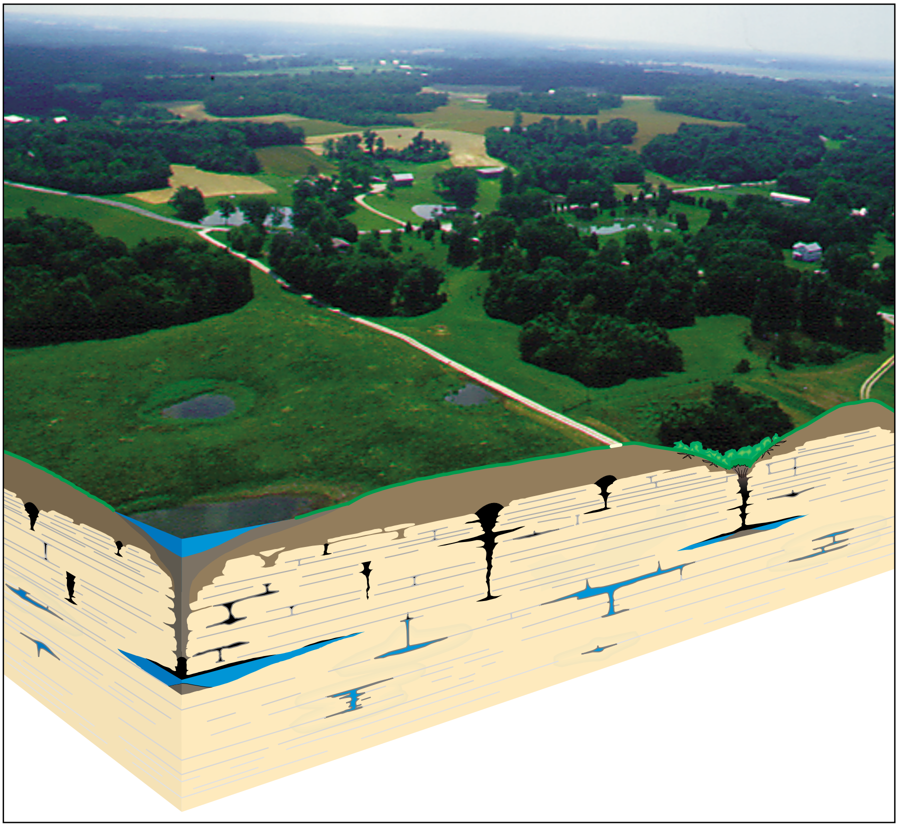


Figure 19 This block diagram of karst terrain shows the relationship between crevices and bedding planes in bedrock and sinkholes on the surface. Groves of trees are often allowed to grow within sinkholes because land within the sinkhole is difficult to use for row crops.

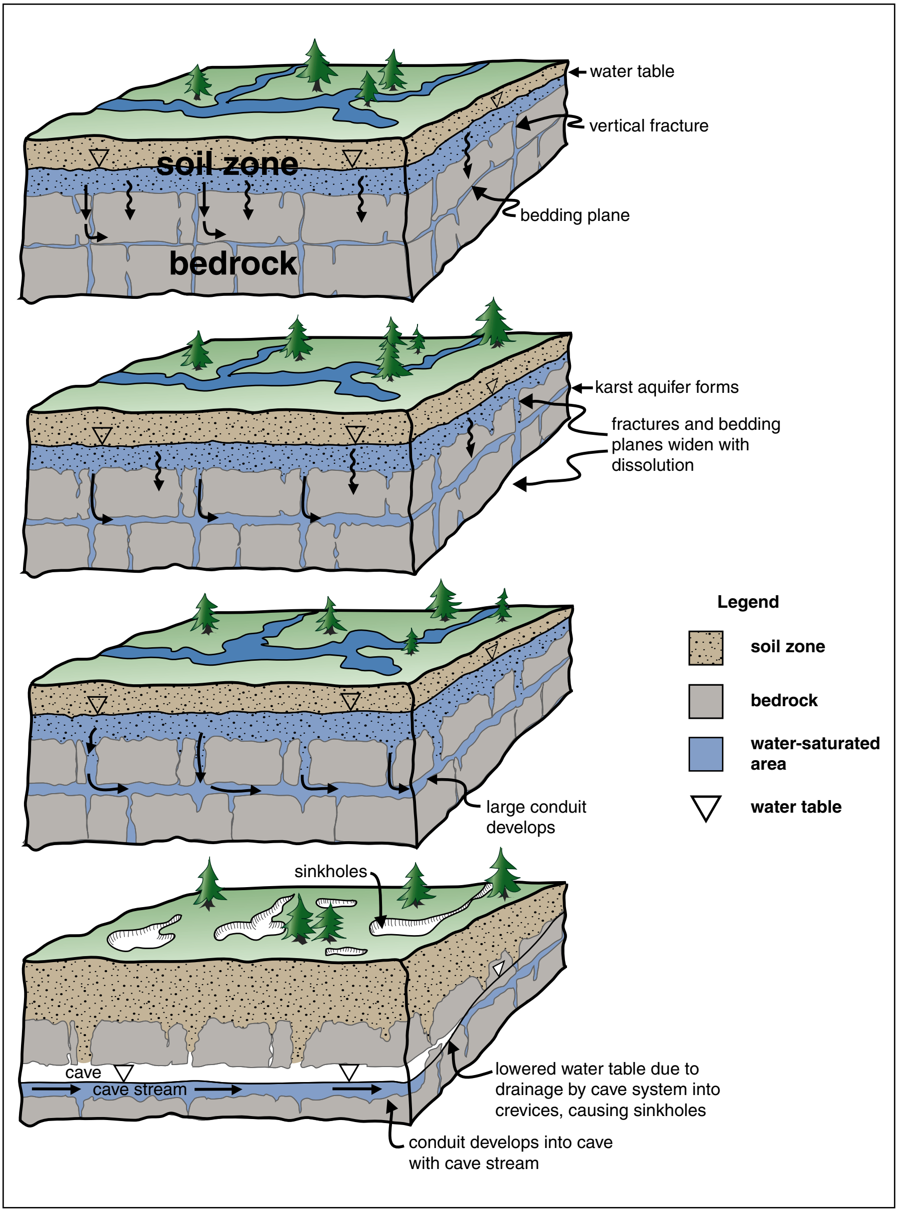


Figure 20 The development of sinkholes and caves in karst terrain. Flowing groundwater enlarges crevices and bedding planes in the bedrock. When a conduit begins to enlarge faster than others nearby, groundwater preferentially flows toward the larger conduit, enlarging it even faster. When the conduit is large enough to become dominant and drain quickly enough that the water table drops to a level within the cave, sinkholes form, and surface streams flow into them or simply disappear. The flow of water in the area is now underground. This is how Illinois Caverns formed.

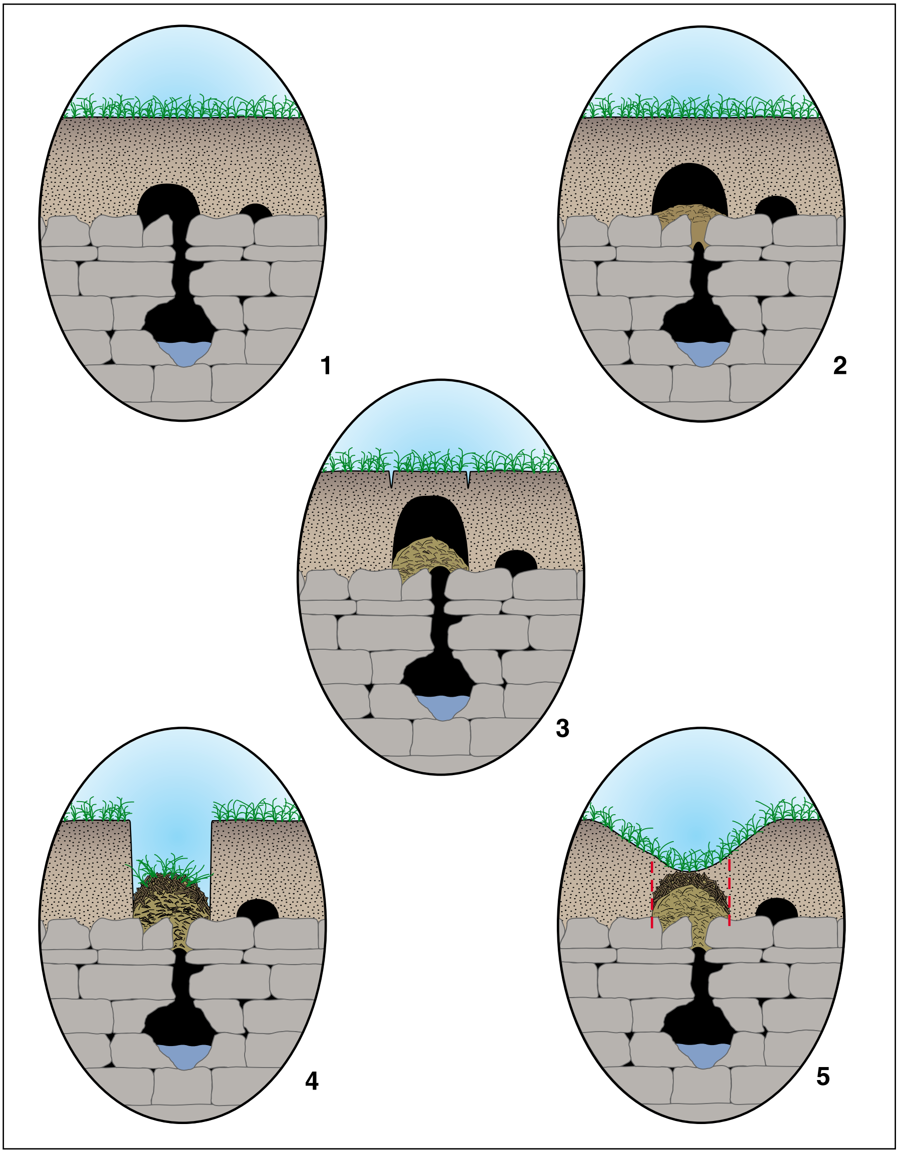


Figure 21 Sinkholes develop where the soil overlying creviced bedrock collapses into a crevice, forming a hemisphere-shaped void in the soil (1 and 2). Groundwater flows through the bedrock to remove the material in the crevice during formation. As soil collapse continues, the void grows upward toward the surface (3), resulting in the eventual collapse of the surface material into a nearly circular hole (4). Erosion smooths out the land surface, forming a bowl- or cone-shaped depression (5). The sinkhole then functions as a small drainage basin, focusing runoff and snowmelt into a conduit system in the bedrock.

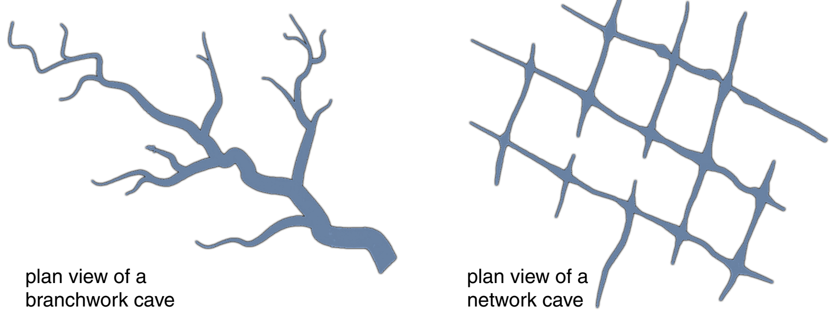


Figure 22 If they could be viewed from above, branchwork caves (left) would be seen to consist of a dendritic (tree-like) arrangement of passages. Network caves (right) consist of a maze of solutionally widened fractures that are typically distributed in a grid-like pattern.

There are two types of caves in Illinois: branchwork caves and network caves (fig. 22). Branchwork caves form when surface water enters the subsurface through sinkholes and along the bedding planes of layered limestone. The water flows along pathways miles in length forming a dendritic pattern similar to the branching of leaf veins. Typically, all of the passages flow toward a main trunk passage that discharges the water from the system. Discharge occurs at a low-lying area at the surface as a spring. Branchwork caves are typical of those found in the southwestern part of the state, including Illinois Caverns. Network caves form when surface water flows into and enlarges a pre-existing set of fractures in limestone or dolomite bedrock. The passages are typically grid-like in their distribution, are tall and narrow, and intersect at nearly 90-degree angles. Network caves are typical in northwestern and, to a lesser extent, far southern Illinois.

Water: An Agent of Change

Water is the reason that the cave exists, or, more precisely, the reason that rock dissolved and is no longer present, leaving the cavity known as a cave. The powerful forces of water—whether as solid ice, flowing water, or expanded gas—create crevices, sinkholes, and caves and deposit rocks, sediments, and minerals. The energy required to initiate and maintain these processes is part of a larger planetary cycle of water distribution and redistribution known as the hydrologic cycle. The hydrologic cycle is a way to describe how water moves to and from the atmosphere, to water and land surfaces, and through soil and living things. Understanding this continuing cycle, and the unique variations caused by karst terrain, is an important part of learning how caves form and continue to change.

The Hydrologic Cycle

During the hydrologic cycle, water evaporates from the surface of an ocean, sea, large lake, or other body of water and rises into the atmosphere as water vapor. As the water vapor rises, it cools and condenses to form clouds. The clouds, moved by the prevailing winds, eventually travel over land. Unstable conditions caused by temperature changes and mixing air masses cause the clouds to lose water vapor, which falls as rain or snow (fig. 23).

As rain or snow collects on the ground, water begins to saturate the soil. With continued precipitation, the soil becomes completely saturated, and water that cannot seep into the soil runs off into low-lying areas that typically contain streams. The small streams flow toward lower areas and empty into larger streams and rivers that eventually take the water back to the oceans, seas, or lakes.

Some water evaporates from the soil to rejoin the atmosphere as water vapor. Some water remains in the soil where it is taken up by plants to be returned to the atmosphere by ***evapotranspiration.*** The remainder of soil water travels through the soil to enter an aquifer. Water from an aquifer may supply water to streams on a regular, long-term basis.

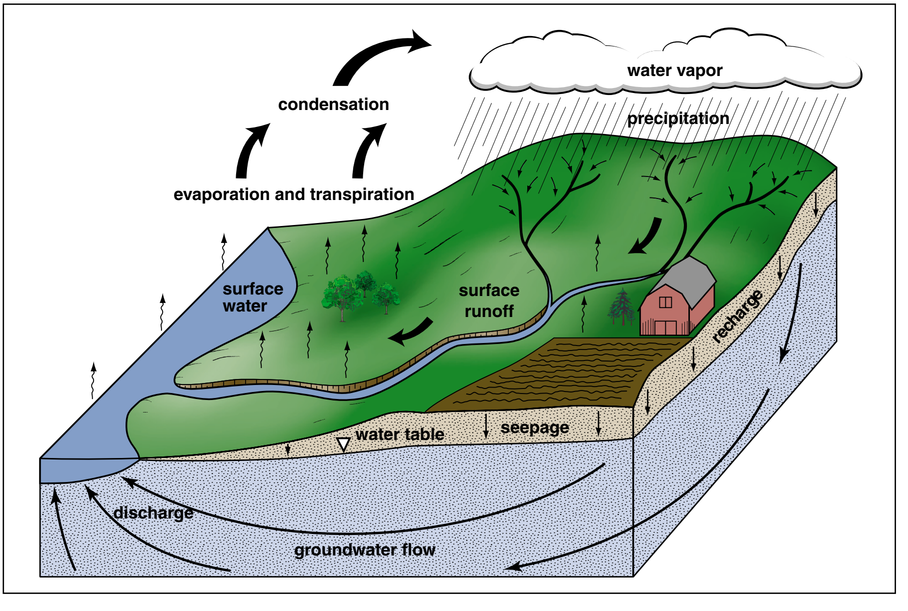


Figure 23 The hydrologic cycle.

The Karst Hydrologic Cycle

What makes the karst hydrologic cycle unique is that there are few, if any, surface streams in karst regions. Streams fed by surface runoff flow directly into caves and smaller conduit systems, commonly through sinkholes that lead directly into the passages of the karst aquifer. Once the water enters the aquifer, it is referred to as groundwater. The surface runoff disappearing into the karst aquifer carries materials from the land surface, including human and animal wastes, pesticides, urban pollutants such as motor oil and road salt, and other wastes that can contaminate the aquifer's groundwater (fig. 24).

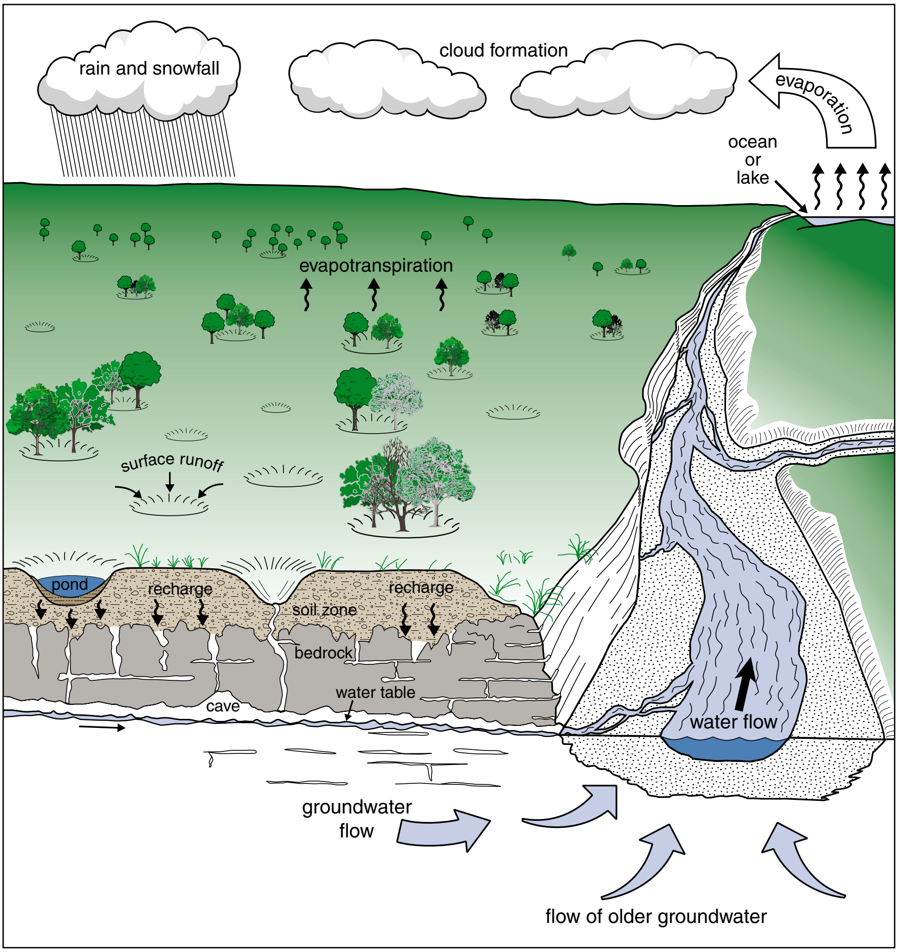


Figure 24 The karst hydrologic cycle.

Water Quality

In non-karst areas, contaminants are “filtered” by their slow passage through soil. In contrast, wells and aquifers in karst terrain are very susceptible to contamination by bacteria, nitrate, pesticides, and petroleum products. Contamination occurs because sinkholes allow surface water, particularly runoff from heavy rainfalls, to enter the bedrock aquifer in a very short time (minutes to hours). Thus, karst areas typically have widespread groundwater quality problems.

Bacterial contamination can completely and permanently alter cave ecology. Potential sources of bacterial contaminants include animal wastes, discharge from private septic systems, and natural sources. Recently, researchers entering a cave in the sinkhole plain to inventory a population of the federally endangered amphipod *Gammarus acherondytes* found that animal or human waste apparently had been dumped into the cave system and had completely wiped out the population.

Potential sources of nitrate in the area include naturally occurring organic matter in soil and human-caused sources such as agriculturally related chemicals from fertilizers and livestock manure and effluent from septic systems.

Pesticides have been found in groundwater samples from caves, springs, and wells in the sinkhole plain, commonly during May and June when pesticides are applied to farm fields. Pesticides also have been found in the tissues of aquatic cave invertebrates in Illinois Caverns and other nearby caves. The effects of pesticides on cave organisms are not well known.

Contamination from petroleum products has been observed in caves near Illinois Caverns. A landowner attempting to pump water for livestock from a small cave pumped black oil instead. The landowner stated that the oil appeared to be used automobile oil. Scientists found a plastic gallon jug filled with used automobile oil in a nearby cave system. Because of the temptation for people to dump materials directly into sinkholes, the contamination potential remains high.

Solid carbonate rock generally does not transmit large volumes of groundwater because it has low ***porosity*** (the volume of the void spaces in the rock) and low ***permeability*** (the ease with which a fluid can flow through it). However, porosity and permeability may be enhanced as the rock is dissolved by acidic water moving along nearly vertical fractures or horizontally along bedding planes. As these conduits and pathways enlarge, the carbonate bedrock eventually becomes a highly permeable aquifer that transmits water rapidly through the passages in the rock. This rapid flow contrasts sharply with other types of aquifers, such as those made up of sand and gravel, that have groundwater flow rates 100,000 times slower. Groundwater from a sand and gravel aquifer can be tens to hundreds of years old, but groundwater within a karst aquifer may be only hours to a few years old.

The acidic water continues to slowly dissolve the surrounding bedrock as it flows toward a discharge point such as a spring. Discharge points are critical because they complete the flow system and remove groundwater from the cave system. Springs are common in karst regions and, in many places, constitute the headwaters of surface streams. Springs typically discharge from cave openings at or near the base of a bluff or as circular pools of overflowing water (probably sinkholes) in a low-lying area (fig. 25). Some springs cycle surface water, soil water, and groundwater flowing into and discharging from the entire ***groundwater basin***. The water quality of these springs is representative of the overall water quality of the surrounding basin. Surface streams formed by springs empty into increasingly larger bodies of water. For example, in the case of Illinois Caverns, the cave water discharges from Dye Spring, enters Horse Creek, then the Kaskaskia River, then the Mississippi River, and finally the Gulf of Mexico where it continues in the hydrologic cycle.

The Role of Water Chemistry in Cave Formation

Water (H_2O) and carbon dioxide (CO_2) play essential roles in cave formation. Carbon dioxide, which can come from many sources, is the key to creating acidic water (fig. 26). Carbon dioxide in the air can become dissolved in rainwater. Carbon dioxide found in the soil zone can combine with water as it passes through. Additional carbon dioxide is produced as soil bacteria consume organic material and plant roots respire. Carbon dioxide concentrations are typically 10 to 100 times greater in soil water than in rainwater because of the greater concentration of carbon dioxide in soil gases. The carbon dioxide that dissolves in the soil water creates carbonic acid (H_2CO_3), which is strong enough to dissolve limestone ($CaCO_3$).

Figure 25 A small, circular spring located at the base of a slope in Monroe County (top) discharges water to a small stream. Terry Spring (bottom) is a cave spring located along the bluff of the Mississippi River and formed along a bedding plane in the limestone. These two springs are typical of those in the sinkhole plain area.

Two carbonate minerals—***calcite*** and ***dolomite***—react with carbonic acid (fig. 26):

Carbonic acid formation: $H_2O + CO_2 \leftrightarrow H^+ + HCO_3^-$.

Calcite dissolution: $CaCO_3 + H^+ \leftrightarrow Ca^{2+} + HCO_3^-$.

Dolomite dissolution: $CaMg(CO_3)_2 + 2H^+ \leftrightarrow Ca^{2+} + Mg^{2+} + 2HCO_3^-$.

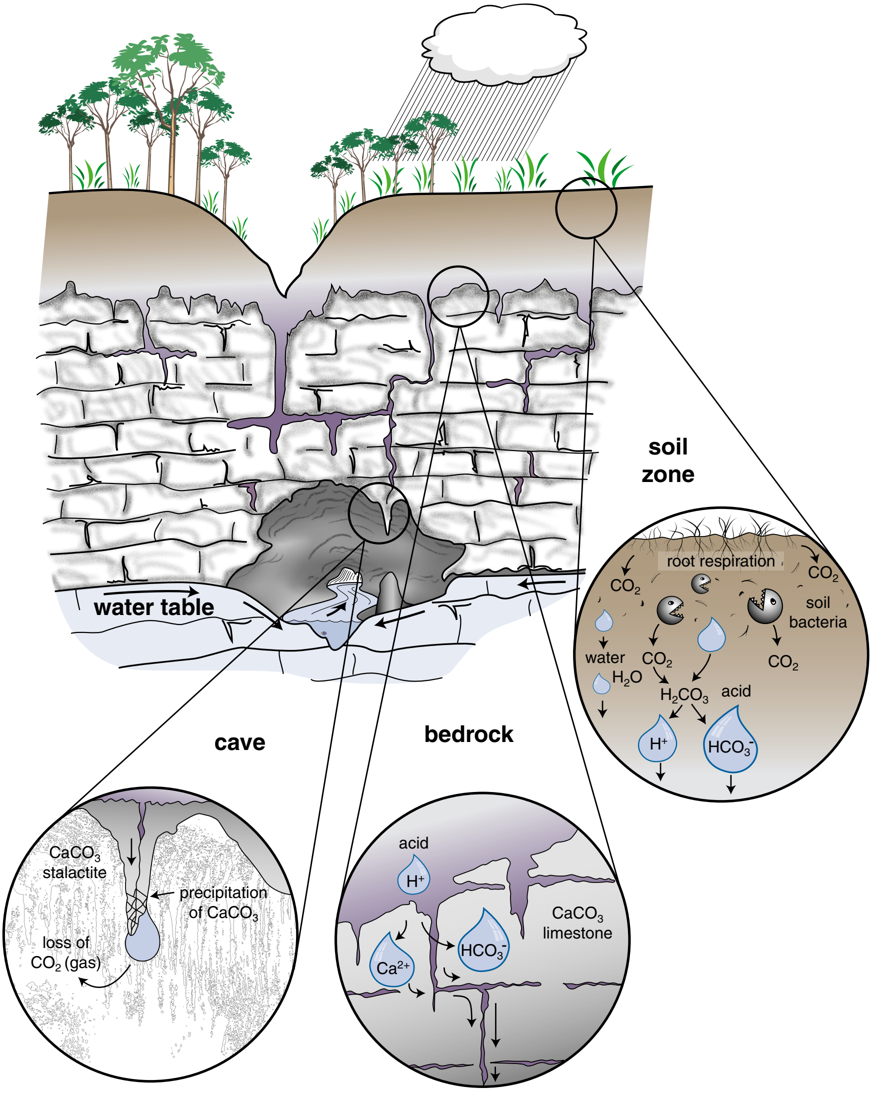


Figure 26 How the carbonate minerals react with carbonic acid.

Carbonate minerals dissolve until the water flowing through the rock becomes saturated with calcium (Ca^{2+}), magnesium (Mg^{2+}), and bicarbonate (HCO_3^-), generally in a matter of days. Despite this rapid saturation, though, dissolving a human-sized pathway in carbonate rock along a conduit system in bedrock takes tens of thousands of years. Eventually, these pathways allow large volumes of groundwater, up to hundreds to thousands of gallons per minute, to flow through them.

The water that typically flows through and discharges from caves as springs or that is found in wells in limestone-dominated karst terrain can be classified as a calcium-bicarbonate type water. The name comes from the dominant ions dissolved in the water: calcium (Ca^{2+}) and bicarbonate (HCO_3^-). The rock the water flows through also is made up of these same two components but as a solid ($CaCO_3$). Although flooding within conduits and caves may dilute the mineral contents of spring water, most of the time the water within the conduits and cave and at their springs is saturated with dissolved carbonate minerals and is referred to as ***hard water.***

The hardness of the water in the Illinois Caverns stream can be calculated as follows: [amount of calcium in the water (91.6 mg/L) × 2.5] + [amount of magnesium in the water (11.0 mg/L) × 4.1] = 274.1. The hardness of water in the Illinois Caverns stream (274.1) is 94 units greater than those waters of the "very hard" category. Because of such hard-water conditions, many residents of the sinkhole plain find it necessary to use water softeners.

Speleothem Formation

Speleothem is the general word for the chemically precipitated rock formations—such as stalactites, ***stalagmites***, and ***flowstone***—that are commonly found in caves (figs. 27, 28, 29, 30, and 31). Some water in the sinkhole plain is so rich in dissolved carbonate minerals that, when it seeps into caves, it forms speleothems through ***degassing.*** Water in the soil zone is under pressure greater than atmospheric pressure, but cave air is at normal atmospheric pressure because caves are connected to the surface. When the soil water enters a cave, the lower pressure allows the dissolved carbon dioxide to escape from the water in the same way that opening a carbonated beverage releases bubbles of carbon dioxide. The loss of carbon dioxide during degassing changes the water's chemistry, and not all of its dissolved calcite can be held in liquid. As the carbon dioxide is released to the cave's atmosphere, calcite is precipitated as a solid (fig. 28).

Progressive precipitation of calcite along the sides and at the end of a growing stalactite increases its length and thickness (fig. 29). Speleothems

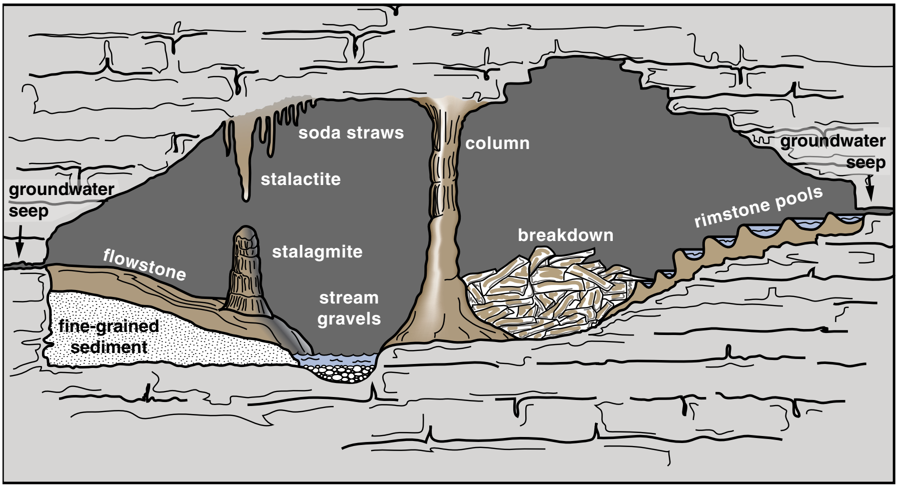


Figure 27 Cave deposits include speleothems (stalactites, stalagmites, columns, flowstone, and rimstone pools) and sedimentary deposits (large slabs of breakdown, smaller stream gravels, and very fine-grained sediment). Combinations of these deposits can complicate their overall appearance.

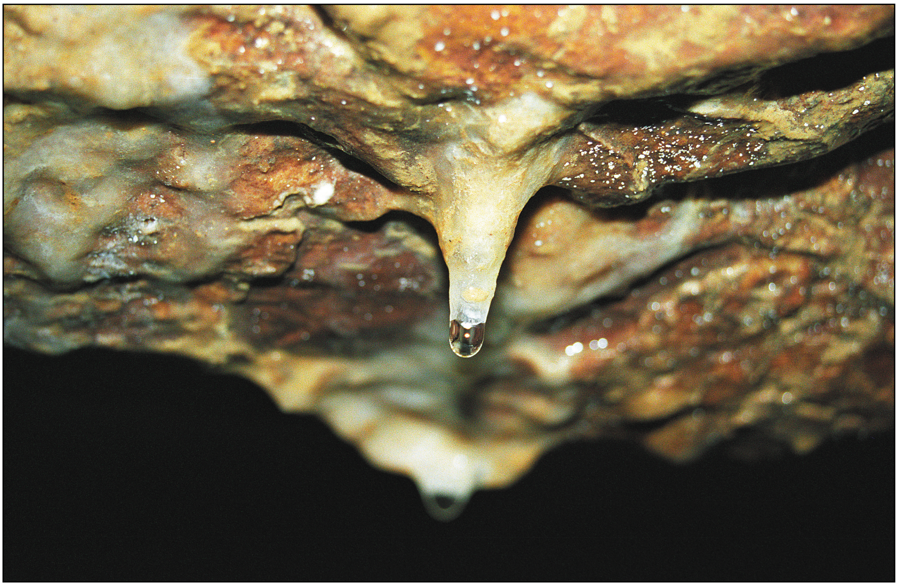


Figure 28 A close-up view of a growing stalactite. The bead of water at the tip of the stalactite (generally between 0.05 and 0.1 milliliters) hangs by surface tension while dissolved carbon dioxide escapes to the cave air. As carbon dioxide is released, calcium carbonate is deposited within the bead of water at the tip of the stalactite.

Figure 29 A cut and polished stalactite shows growth rings that probably represent thousands of years of growth. Different colors of bands may indicate changing climatic and/or hydrologic conditions on the surface and in the bedrock overlying the stalactite.

Figure 30 A stalagmite sliced in half vertically shows growth ring patterns that can be dated. Nearly vertical cavities close to the base of the right half are caused by dimpling of the top of the stalagmite and the collection of water within the stalagmite during growth. Preliminary age dating of the stalagmite shows it to have started growing about 4,500 years ago.

commonly grow only thousandths of an inch per year. However, in some cases, growth can be as rapid as 0.3 inches per year for a stalagmite and 0.2 inches per year for a stalactite. The growth rate depends greatly on the drip rate, the concentration of calcium carbonate in the water, and the degree of agitation of the water as it drips or flows. For example, a rapid influx of calcite-saturated water can create a large (3 feet high), very porous stalagmite in a relatively short time (thousands of years). A slow influx of water saturated with calcite can create a small (less than 1 foot), densely crystalline stalagmite over the course of tens of thousands of years.

Speleothems in Illinois Caverns range in color from white to black, but most are shades of brown. Organic compounds dissolved in the water depositing the speleothems typically control the color. The compounds are derived from the decaying vegetation on and within the soil and were picked up by the water as it migrated downward toward the cave. Pure white speleothems contain very low concentrations of organic compounds, but dark brown to black speleothems generally were deposited by groundwater containing high concentrations of organic compounds and/or ***manganese*** and ***iron*** (fig. 31).

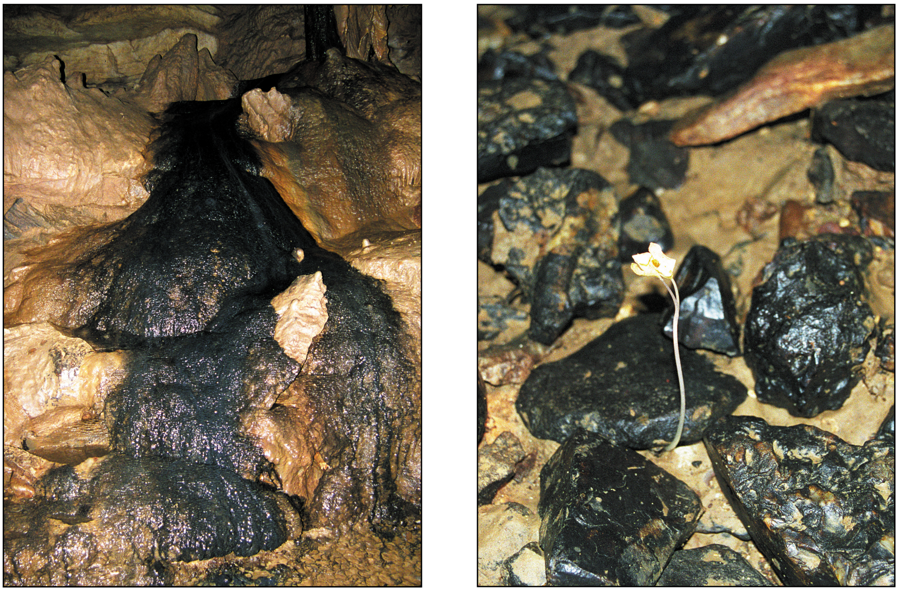


Figure 31 Groundwater containing little oxygen and dissolved iron and manganese mix with oxygenated cave water, causing the metals to precipitate as a black coating 0.04 to 0.40 inches thick onto any available cave surface, such as flowstone (left) and stream gravels (right).

THE PLANTS AND ANIMALS OF THE ILLINOIS CAVERNS STATE NATURAL AREA

Unique Natural Features and Vegetation

The Illinois Caverns State Natural Area is being closely managed by the Illinois Department of Natural Resources to restore the unique natural features and vegetation on the surface and to preserve natural areas in the cave. The original land surveyors described the area before settlement as a post-oak ***barrens***, “rolling, broken (***saseimensa*** or barrens) with sinkholes, undergrowth oak shrub and grapes, timber scattering, thin oak land” (fig. 32). One early description of western Illinois during 1836 seemingly defines barrens quiet simply as “neither timber land nor prairie, but partaking partly of each, and lying between them.” A description of the land near Illinois Caverns in 1838 mentions openings and broken ground composed of large trees of the various kinds of oaks, hickory, maple, and elm.

The Barrens

A barrens consists of two components: (1) strong trees that can survive the onslaughts of savage prairie fires and (2) enduring grasses, which hold their ground against encroaching woody species. Many species of plants and animals thrive within the barrens, co-evolving and interdependent. For example, ladies’ tresses, *Spiranthes cernua,* is an ivory, tall-stemmed orchid. The orchid emits a fragrance that attracts a certain sphinx moth, the only insect that can pollinate it. Insects also depend on the showy flowers of the Asteraceae family (fig. 33). On the woodland floor, spring-blooming flowers such as the common blue violet, *Viola papilionacea,* provide nectar to feed bees and early butterflies.

The variation in habitat within the barrens allows for great diversity (often referred to as biodiversity) in animal life, ranging from the tree-dependent eastern gray squirrel to the grazing white-tailed deer. The habitats nurture wetland inhabitants such as salamanders and frogs and also upland dwellers that nest on the ground, including the bobwhite quail and eastern cottontail rabbits.

A Surface Tour

The plants and animals of Illinois Caverns State Natural Area vary seasonally. During summer, you may see black-eyed Susan, *Rudbeckia hirta* (fig. 34). The tall, yellow-flowered *Silphium laciniatum* earned its common name, compass plant, by the tendency of its large, deeply lobed leaves to orient themselves in a general north-south direction. Pioneers sometimes marked the edges of wagon routes over the wild prairies by tying scraps

Figure 32 The original landscape of the sinkhole plain was a post-oak barrens of gently rolling land covered by prairie plants and clusters of oak, hickory, and other deciduous trees and woody vegetation similar to the barrens shown above. Big bluestem, *Andropogon gerardi* (at right), is a common prairie grass that grows in clusters to a height of 6 feet.

Figure 33 The gray-headed coneflower, *Ratibida pinnata* (top), and purple coneflower, *Echinacea purpurea* (bottom), are members of the sunflower family (Asteraceae) and are common prairie plants.

of cloth to the tall plant stems. When in bloom, a compass plant's cut stem exudes a gummy material that Native Americans and pioneers may have used as chewing gum.

On the restored prairie at the natural area, you may also see purple blazing star, *Liatris pycnostachya* (fig. 35). Butterfly milkweed, *Asclepias tuberosa,* attracts the monarch butterfly, *Danaus plexippus,* and the tiger swallowtail, *Pterourus glaucus.* Goldenrod, *Solidago* sp. (fig. 36), attracts the monarch and the slender black-marked, orange-winged soldier beetle, *Chauliognathus pennsylvanicus.* The larvae of *Celastrina argiolus,* an intensely blue butterfly, feeds upon the white blooms of a bushy New Jersey tea plant, *Ceanothus americanus.* This plant also attracts ants.

Also found at Illinois Caverns are two 6-foot-high grasses. Indian grass, *Sorghastrum nutans,* has plumelike flower clusters dropping from small twisted bristles. *Andropogon gerardi,* commonly known as big bluestem or turkeyfoot grass (fig. 32), is abundant. Beneath these giants grow clumps of side-oats grama, *Bouteloua curtipendula,* and rattlesnake master, *Eryngium yuccifolium* (fig. 37).

Figure 34 The black-eyed Susan, *Rudbeckia hirta*, is abundant within prairies, along highways, and in flower gardens.

Figure 35 The prairie blazing star, *Liatris pycnostachya*, is used in gardens.

Figure 36 Goldenrod (*Solidago* sp.) is a common prairie plant found along highways because of its propensity to thrive in disturbed ground.

Figure 37 Rattlesnake master, *Eryngium yuccifolium*, bears ball-like compact flower heads of tiny, white flowers and pointed green bracts (small leaves that are part of flowers). Blue-green linear leaves with needle-tipped, fang-like edges clasp the stout stem.

Figure 38 The American kestrel, *Falco sparverius,* looks for prey.

Birds frequenting the barrens include the somewhat secretive Henslow's sparrow, *Passerherbulus henslowii,* which has a stump tail, brown plumage, and a dark-striped green head. In contrast, the American goldfinch, *Spinus tristis,* has distinctive, nearly luminous yellow plumage. A small, grayish bird, the eastern phoebe, *Sayornis phoebe,* is often found perched on twigs and builds dried moss-lined nests of mud and grass on limestone outcrops. The red-headed woodpecker, *Melanerpes erythrocephalus,* can also be found near the oak trees. One of the more majestic birds in the region is the American kestrel, *Falco sparverius* (fig. 38). The slate-blue wings and rust-colored back of the sparrow hawk catch the sunlight, and its sharp-sighted dark eyes are accentuated by black stripes on white cheeks. These raptors scan the barrens for the slightest movement of their small mammalian prey.

Cold-blooded reptiles include the prairie kingsnake (fig. 39), *Lampropeltis calligaster calligaster;* its straw-colored, long and slender body provides the camouflage necessary to stalk its prey, such as the southern bog lemming, *Synaptomys cooperi.* The western ribbon snake, *Thamnophis*

Figure 39 The prairie kingsnake, *Lampropeltis calligaster calligaster.*

proximus proximus, has a distinctive, brightly striped, jet-black body (fig. 40). This efficient hunter frequents cool limestone crevices and sinkhole ponds during the hottest part of the day and preys, among other things, on the southern leopard frog, *Rana sphenocephala*. Another inhabitant is

Figure 40 The western ribbon snake, *Thamnophis proximus proximus*.

Figure 41 The male variable dancer damselfly, *Argia fumipennis violacea*.

the black salamander with small white spots, *Plethodon glutinosus,* which can be found hiding beneath leaf litter and also within Illinois Caverns.

Insects in the ponds and grasses of the barrens provide food for the birds and frogs. Well-known inhabitants of the grasses include the violet-colored, male variable dancer damselfly (the female has a black abdomen), *Argia fumipennis violacea* (fig. 41), grasshoppers, and crickets.

Life in the Subsurface

Beneath the bright, colorful world of grasses, flowers, birds, and insects, lies the dark, moist world of the cave (fig. 42). Yet even deep within the cave, where both humidity and darkness are at or near 100%, there is much to be seen in the beam of a flashlight. Stopping a moment at the stream bank before taking a step may allow you to catch a glimpse of an isopod or an amphipod (fig. 43).

Both are tiny invertebrate animals belonging to the phylum Arthropoda, the taxonomic group of insects, spiders, scorpions, and crustaceans. The class name, Malacostraca, meaning “soft” and “shell,” undoubtedly describes the exoskeleton or cuticle. This exoskeleton is unique because it is flexible and lightweight, soft and permeable, yet tough and insoluble in water and weak acids. Thus, the isopods and amphipods are well suited for their lives in the waters that dissolve limestone and create the cave.

With eight thoracic and six abdominal body segments, each with a pair of appendages, these animals are well-named; Isopoda means “equal” and “foot,” and Amphipoda means “on both sides” and “foot.” The numerous appendages serve sensory functions, handle food, and allow for swift and efficient maneuvering. The isopods of the cave are generally pale and have elongated bodies. Amphipods somewhat resemble the larger oceanic plankton known as krill.

Scientists studying the fauna of the sinkhole plain of southwestern Illinois have observed diverse populations of arthropods, flies, cave cricket nymphs, fleas, braconid wasps, staphylinid and carabid beetles, spiders, millipedes, diplurans, and isopods and amphipods. Collembolans, minute wingless insects better known as springtails, with forked tail-like jumping mechanisms, were also found.

Figure 42 The entrance to Illinois Caverns (looking up from the cave) is an east-west–trending crevice that has been enlarged by the inflow of slightly acidic rainwater, snowmelt, and soil water that dissolved the limestone.

Figure 43 Two crustaceans common to Illinois Caverns are the amphipod *Gammarus acherondytes* (above) and the isopod *Caecidotea brevicauda* (to left). Both of these organisms are only about 0.2 inches in length. They live in the stream and stream gravels and eat bacteria and organic debris brought in from the surface.

Endangered Species of Illinois Caverns

A small organism native to Illinois Caverns and also on the federally endangered species list is *Gammarus acherondytes.* Known as the Illinois Cave Amphipod (fig. 43), this creature has been found in only a few caves in Monroe and St. Clair Counties, Illinois, and exists nowhere else in the world. Because this endemic species is susceptible to disturbance, it is classified as imperiled and was listed as both a state and federally endangered species in 1999.

The entrance to Illinois Caverns is guarded by a gate that is intended to limit public access to authorized visitors. It is important for visitors to realize that natural, geological, or biological materials may neither be removed from the cave nor disturbed under penalty of law. Removal or disturbance of these materials would eventually destroy the natural beauty of the cave and upset the delicate ecosystem within.

Bats

On the ceiling of Illinois Caverns, *Myotis lucifugus,* the little brown bat, or *Pipistrellus subflavus,* the eastern pipistrel bat, is likely to be seen hanging upside down (fig. 44). Like many other Chiroptera, meaning "hand" and "wing," these bats use the cave as a roosting site. Because bats are nocturnal, they may rest in the cave during the day and spend the night capturing insects with their mouths or by scooping them into their wings and tail membranes and then into their mouths. Bats can visually detect prey, but typically locate their prey using ***echolocation***.

During winter, Illinois Caverns serves as a suitable place for bat hibernation, when the bats' metabolic rate lowers and body temperature drops almost to the ambient temperature of the cave. Heart and breathing rates are drastically reduced to avoid the need to eat since food is not available for bats in the winter. During summer, within certain caves where large rooms and warm conditions are suitable for bearing young, bats may establish maternity colonies.

Figure 44 Two bats common to Illinois Caverns are the eastern pipistrel, Illinois' smallest bat (*Pipistrellus subflavus*), and the little brown bat (*Myotis lucifugus*). Both bats hibernate during the winter in Illinois Caverns and other area caves. The Eastern pipistrel is shown at rest hanging upside down from the cave ceiling. The little brown bat is shown flying through the cave.

Figure 45 The Eastern box turtle, *Terrapene carolina* (top), is an accidental cave inhabitant and probably fell into the cave through the bottom of a sinkhole. The turtle probably will die in the cave and serve as food for its other inhabitants. A harmless black rat snake, *Elaphe obseleta* (bottom), is shown lying along a bedding plane within a chimney near the cave entrance. The snake entered the chimney through pathways in the soil zone and through the top of the bedrock.

Some cave creatures are categorized as ***troglobites*** because they depend on the cave environment and are restricted to life within the cave. However, bats are ***trogloxenes***—cave visitors who must leave the cave during their life cycle. Above ground, bats feed upon nocturnal insects such as mosquitos. Within the cave, bats leave behind droppings, called guano, which becomes an important source of nutrients for other cave creatures. In fact, caves with bat populations tend to have numerous other animals because of the bat droppings.

The Surface Connection

In the sunless world of the cave, where the green plants of the surface do not grow, the first link of the food chain is organic material that has entered the cave. Leaves and twigs may fall or be carried into the cave by runoff. The cave ecosystem also depends on bats, raccoons, mice, cave crickets, snakes, accidental inhabitants, and other organisms (fig. 45) that live in or regularly visit the surface world. These organisms leave behind fecal material, which provides nutrients for certain species that feed directly on the waste or graze upon the bacteria and fungi growing on it. Grazers such as the springtail and bristletails, beetles, and millipedes are fed upon by spiders and other predatory animals.

One such predator frequenting Illinois Cavern's twilight zone, an area near the entrance that is somewhat illuminated during the day, is the black and white spotted, terrestrial salamander *Plethodon glutinosus glutinosus.* Like other ***troglophiles,*** this salamander could spend its entire life within the cave, but often forages at night outside the cave, eating primarily arthropods. Another salamander, *Eurycea lucifuga,* can also be found within the cave. This slender, medium-sized, bright reddish orange troglobite has numerous black spots scattered over its back and sides (fig. 46). Adults and transforming larvae can be found together in ***rimstone pools*** and ***potholes***.

The moist, shaded bluff of the cave entrance is a unique habitat upon which ferns, mosses, and liverworts may grow and birds may nest, and through which reptiles, raccoons, spiders, and salamanders may pass. Despite the insulating effect of the cave's surrounding layers of rock, which creates a stable cave climate, air currents within the cave respond to changes in surface barometric pressure and temperature. These climatic changes produce a pattern of air flow to which the cave's wildlife has become accustomed.

Figure 46 The orange and black spotted *Eurycea lucifuga* (top) and the terrestrial, black and white spotted *Plethodon glutinosus* (bottom). Both adult salamanders are about 8 inches in length.

TOUR OF ILLINOIS CAVERNS

Welcome to Illinois Caverns! This self-guided walking tour provides information on the geologic and hydrologic features encountered within the cave.

Before You Begin Your Tour

The tour begins at the entrance, progresses downstream, and then returns along the same route to exit at the entrance point. The length of time required for the tour varies depending on the individuals, the size of the group, the traffic in the cave at the time of the tour, and the amount of time spent at each location of interest. The estimated times are those required for a group of about fifteen school-age children walking downstream from the entrance at a leisurely but steady pace to reach each described area. Group leaders should allow additional time for planned stops. If you are in a smaller group of older, experienced cavers and make few if any stops, then divide the travel times by 4.

Illinois Caverns is a natural system and provides a unique situation for instruction, along with some challenges. The cave passage is relatively narrow, and visitors must walk single file in many places. The cave's acoustics are not always conducive to intelligible conversation among more than five or six people. The cave's cylindrical shape and its smooth rock surfaces create many echos, and the movement of people through the stream makes a great deal of noise. Educators and group leaders should plan their trip carefully and have a high escort-to-student ratio. Plan stops along the way in areas where students can congregate and focus on the group leader and where all can see, examine, and discuss the feature(s) of interest. Tour leaders should impress upon the participants the importance of leaving the cave, its speleothems, and members of its ecosystem undisturbed.

Illinois Caverns is currently the only large cave in Illinois that is open to the general public without permission from a landowner. Permission from the site interpreter is required. At the time of this writing, all tours are self-guided.

Cave explorers must bring the following:

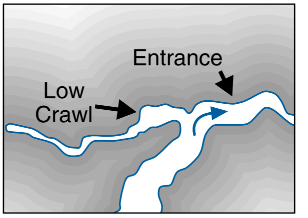
- lights (at least three, plus extra batteries)
- hardhats or bike helmets
- craggy-soled boots (many places are slick)
- gloves and long pants
- water for hand washing and drinking

A change of clothing is recommended. Cavers should expect to get their boots and pants wet and to be dazzled by the beauty of Illinois Caverns and its natural setting. The cave system and its inhabitants are fragile and should be treated with care and respect.

Please take nothing but photographs and leave nothing but footprints during your visit.

At this writing, not all areas within the cave at the Illinois Caverns State Natural Area are owned by the state. Because property boundaries may be subject to change with the acquisition of land, please consult the site interpreter as to the current location of the state boundaries. If your party wants to go beyond the designated state-owned property, it is necessary to get permission from the owners of the adjacent land to avoid trespassing on private property. The site interpreter can give you information as to how to contact the landowners.

The Cave Entrance

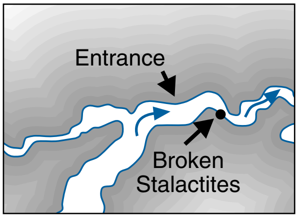


Approaching the entrance to Illinois Caverns (fig. 47), you walk along a trail to a sinkhole with an exceptionally large crevice at its bottom. The dimensions of the crevice are approximately 70 feet long and 10 to 15 feet wide. There is a 90-foot drop from the rim of the sinkhole through the crevice to the floor of the cave. Early cave explorers used a series of oak ladders to enter the cave because of the steep sides of its entrance and the abrupt drop into the cave. Several generations of wooden stairs have been constructed since then, and today you descend into the sinkhole on a wooden stairway, through the rock-walled crevice, and down to the floor of the cave on a set of steep concrete steps installed by the Illinois Department of Natural Resources in the late 1980s.

As you descend through the opening, you can see the bedded or layered limestone bedrock that lies beneath the soil. The crevice walls are covered with mosses, lichens, and ferns that thrive because of the moist air coming from the cave. The limestone bedding planes are accentuated by dissolution and the moss cover (fig. 47). During the winter, icicles that form along the crevice walls look like the flowstone and small stalactites of calcite in the cave. No matter what the season, ***you are encouraged to hold onto the handrails while descending the concrete stairway into the cave***. Descending the stairway, you are enveloped by a humid darkness that may feel warm in the winter or cool in the summer. The relatively constant air temperature (approximately 54°F) within the cave is a function of the insulating properties of overlying soil and rock and the constant temperature of groundwater flowing into and through the cave.

The cave entrance originated as an east-west–trending fracture in the limestone bedrock (fig. 42) that formed, in part, over the main passage of Illinois Caverns. Slowly, soil water flowing downward into crevices and cracks in the bedrock, on its way to the ever-enlarging cave below, began dissolving the walls of the fracture. The funnel shape of the sinkhole focused rainwater and snowmelt into the crevice, causing even more limestone to dissolve and eventually exposing the rock to surface weathering.

The Cave (1 minute from the entrance)



Descending through the cave ceiling, you will notice that the sounds from the surface quickly diminish, and cave sounds begin to dominate. However, the soft splashing of the cave stream may be punctuated by echoing voices, reverberating thumps of boots, and resounding bumps of hard hats against the ceiling. Maintaining quiet within the cave may increase your group's pleasure. Everyone in your party should step away from the entrance and stand for a few minutes in the adjacent darkness (taking care not to fall into the stream) so that your eyes have time to adjust from daylight to the very low light conditions in the cave. Upon your return from the cave's darkest reaches, you will be amazed at how brightly lit the cave entrance appears.

There may be a light fog present as you enter the cave. The fog is due to cave visitors exhaling humid air that is approximately 98°F, which condenses when it meets the cooler cave air (approximately 54°F). A light fog may also form at the entrance when humid summer air of about 70°F or higher encounters and mixes with the cooler cave air.

Walking downstream from the entrance, you will see the most extensive part of the cave. You are completely surrounded by the bedrock limestone laid down during the Mississippian Period. Imagine, for a moment, the environment in which the limestone formed. Think back to a time when Illinois was covered by a quiet, warm, sunlit ocean. The ocean water is home to countless microscopic and macroscopic organisms that form calcium carbonate shells and live, suspended, in the upper parts of the ocean. As these organisms die, their shells rain down, at a steady rate, onto the ocean floor where larger-shelled organisms live and die. Storms create currents and conditions that result in the influx of fine mud into the area. When the stormy conditions end, the fine mud, suspended in the turbulent water, settles out and covers the shells and shell fragments already laid down. That thin, almost imperceptible layer of fine mud may be visible as a bedding plane millions of years later when the deposits have become rock.

Figure 47 The moss-, fern-, and lichen-covered entrance to Illinois Caverns is a transition zone between the sun-seeking plants and animals on the surface and the damp, dark world of a unique group of organisms living below ground. In the photograph, the thin boundaries between the finely layered beds of limestone are accentuated by the transitional vegetation.

Cross-Sectional Shape of Cave Passages

The cross sectional shape of cave passages provides a clue to the cave's origin (fig. 48). Illinois Cavern's canyon-shaped passage suggests it was dissolved by a cave stream (with an air space above it) that continually cut down into the rock stream bed. The cave stream continues to flow along the bottom of the passage, dissolving and abrading the cave floor.

Caves that form under partially water-filled conditions are known as vadose caves, and caves that form underwater are referred to as phreatic caves. Vadose conditions occur when groundwater flows through fractures and along bedding planes with an air space above the water, dissolving the rock in a downward direction.

Phreatic conditions occur when groundwater totally fills and flows through fractures and along bedding planes, dissolving the rock equally in all directions. Phreatic conditions form an elliptical-shaped passage that appears as a horizontal tube. The keyhole shape is a modification of the ellipse that occurs when formerly phreatic conditions gave way to vadose conditions and a canyon-like downcutting occurred in the floor of the tube.

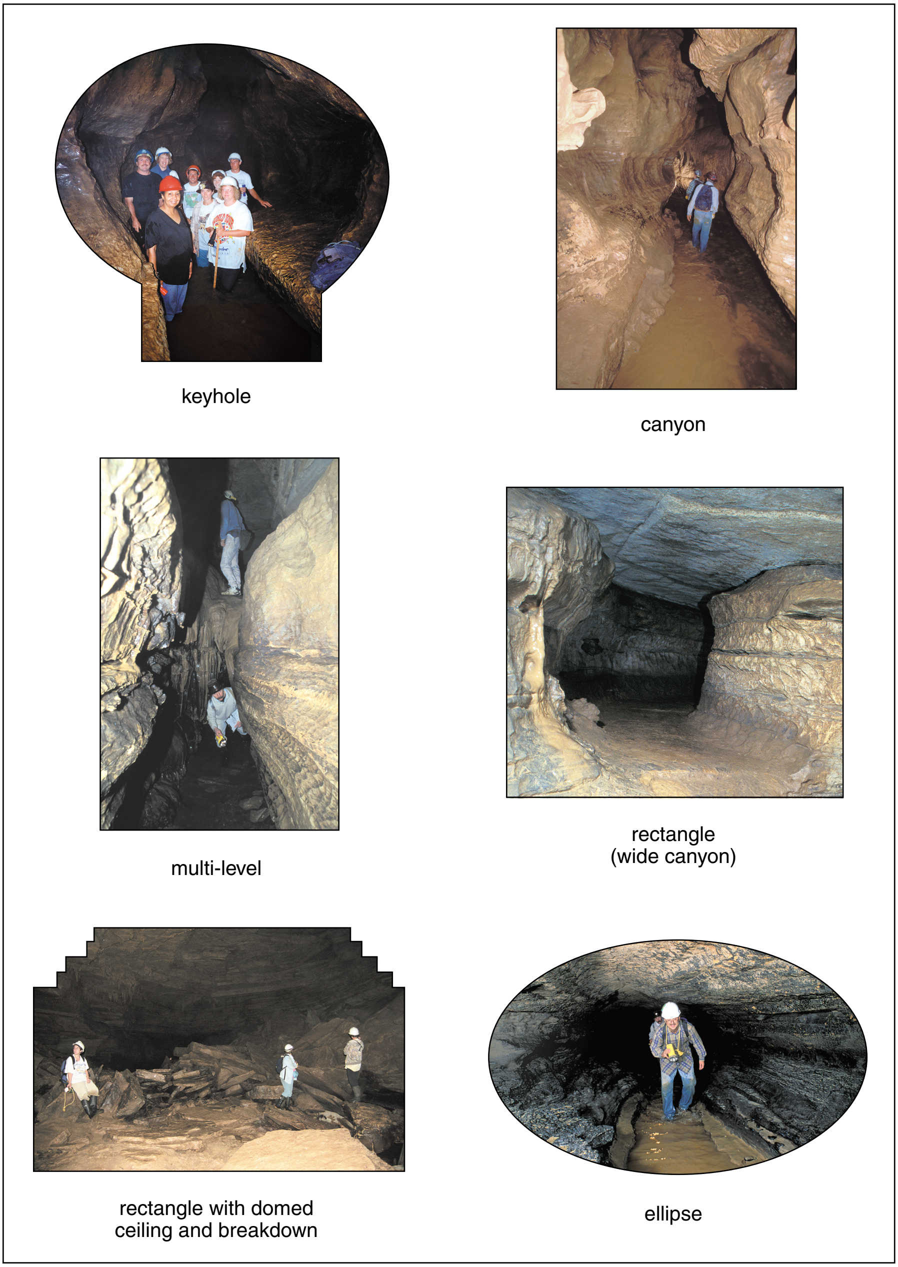


Figure 48 These six cross sectional shapes of cave passages in Illinois Caverns reveal much about their origin and evolution. The rectangular shapes (including the canyon) are formed by water flowing through bedrock with an air space above the water. The ellipse is formed when the passage is completely filled with water. Combinations of these two conditions, and filling of the cave with sediment and/or speleothems, can significantly alter these shapes.

Chert

Chert is made of microscopic quartz crystals (silicon dioxide, or SiO_2) arranged in a random orientation. This flint-like rock is the same type of material used by local Native Americans to make arrowheads and other stone implements found in the area. However, because of the abundance of chert outside the cave, and because of the difficulty in entering and exiting Illinois Caverns, Native Americans probably did not use the cave as a source for chert.

The chert in the cave formed some time after the limestone beds were deposited. Silica-rich groundwater infiltrated the limestone, probably along bedding planes, and mixed with water flowing through the carbonate bedrock. The ensuing chemical reaction caused chert to be precipitated and deposited into void spaces dissolved within the limestone, both as distinct nodules and as relatively thin beds between bedding planes. Nodules may be fist size or smaller, but layers may extend for many feet and be several inches thick. Because chert is considerably less water-soluble than limestone, it is left behind as the limestone dissolves. Nodules and layers of chert may be seen weathering out of the limestone within the cave (fig. 49).

Figure 49 Chert nodules protrude from the smooth limestone of the cave walls.

The Stream

The stream (fig. 50) is an excellent means of orienting yourself when following this guide. You should initially travel downstream and need only travel upstream to find your way back to the entrance.

The dynamic nature of the stream makes it an integral part of the cave and its ecosystem. The stream grows and changes by dissolving bedrock and by moving and depositing sediment throughout the cave. The stream was responsible for forming the cave in the past and continues to enlarge the cave and create features along its pathway.

The stream that flows through Illinois Caverns all year is fed by groundwater draining from the bedding planes and crevices in the adjacent bedrock and from surface runoff that enters the cave through sinkholes. Typically, the stream water is clear and cold, but, during periods of high rainfall, runoff water rushes into the sinkholes on the surface, drains into the bedrock, and pours into the cave stream. When this happens, the stream level in the cave rises, and the water flows faster and becomes coffee colored. The color comes from the suspended sediment load that the stream carries: particles of clay, fine silt, and organic debris from the glacial deposits (drift) and soil on the surface.

During high rainfall, trapped soil water that has been pooling on top of bedrock and dissolving manganese and iron is forced into the karst aquifer and channeled into the cave. The blackened pebbles and cobbles in the stream bed are made of chert and limestone fragments that have been coated with a thin layer of manganese and iron oxides (fig. 31).

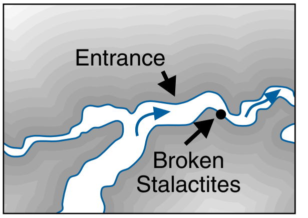
Following saturation of the soils on the surface, runoff begins to flow into the cave from sinkholes. Both waters combine to form a weakly acidic water that dissolves more limestone bedrock and enlarges the cave. Between these rain events, the cave stream water is typically alkaline and cannot dissolve limestone. Thus, flooding events are the main agents of change in Illinois Caverns and most other caves.

The deposits of sand, gravel, and fine silt found throughout the cave are clues as to how fast the cave stream flows at various times and places and how much sediment the stream commonly carries. A fast-moving stream has great energy and can carry large particles and rock fragments that can abrade the cave floor and walls like sandpaper against wood. For example, a flood flashing through the cave might be able to move cobbles up to 1 foot in diameter, but the slow-flowing stream at normal levels may be able to carry only very small sediments about the size of flour particles. The actions of the cave stream result in the formation, over time, of many cave features, including ***scallops*** and potholes.

The stream helps maintain constant temperature and humidity within the cave. The cave stream also is a habitat for a variety of aquatic life that includes bacteria, amphipods, ostracods, ***copepods,*** amphibians (frogs and salamanders), and fish. Accidental inhabitants, those organisms that fall in or are washed into the cave through a sinkhole, may also live in or near the cave stream.

Figure 50 The cave stream is the main force generating and changing the cave.

Broken Stalactites (12 minutes)



About 100 feet downstream of the entrance, just before the cave begins to narrow, you can see on the cave ceiling what once was a field of stalactites. This area is up a small slope to your right as you walk downstream from the stairway. Many of these stalactites once were as long as 1 foot or more (figs. 51 and 52). It is unfortunate that this area has been denuded because it cannot be restored; you can only imagine how the field of stalactites originally looked. The remaining evidence suggests that the stalactites were broken off somewhere between 50 and 100 years ago when the cave was first explored and opened to tourists. If the broken stumps are inspected closely, straw-shaped stalactites about 1 inch or so in length can be seen forming on the stumps of the stalactites. Droplets of degassing water may be visible at the end of each tiny stalactite. This area exemplifies the effects of souvenir collecting in a cave. It will probably take 500 years or more before the stalactites regrow to their original size, and not all of the stalactites will continue to grow. A close look at the broken ends of the larger stalactites reveals growth rings similar to those of a tree. Changes in climate, interruptions in stalactite growth, and major flooding are all recorded in the growth rings of speleothems.

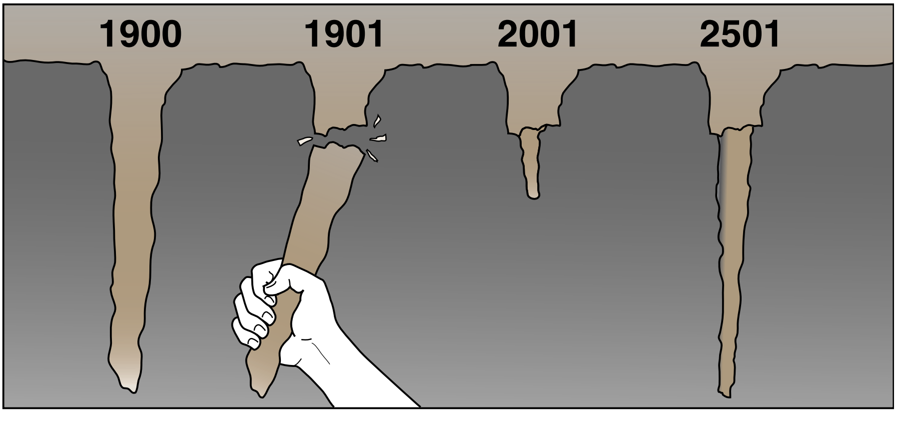


Figure 51 At the average growth rate, if a 6-inch stalactite were broken off in the year 1901, regrowth would be about an inch in 2001 and close to its original length in 2501, although its appearance would be modified.

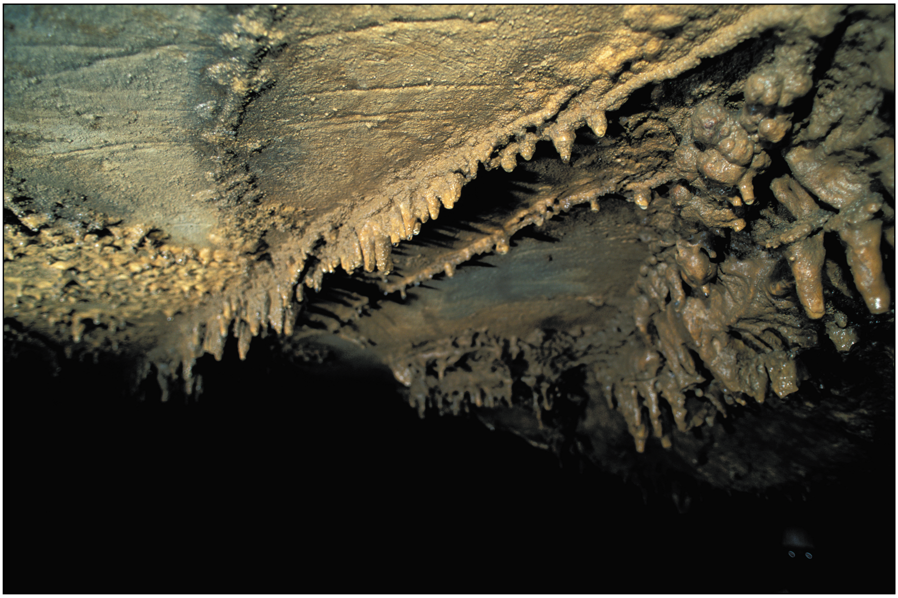
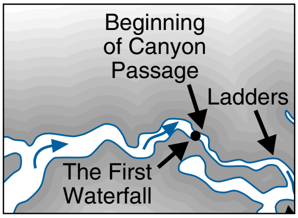


Figure 52 Stalactites tend to form along fractures in the limestone ceiling (top). A line or linear cluster of stalactites is probably fed by a fracture system that extends up to the overlying soil zone. One-inch stalactite regrowth from the stumps of their broken ancestors (bottom).

Cave Vandalism

Cave vandalism is the destruction or defacing of a cave, its environment, and its life forms (figs. 51 and 52). Environmental vandalism in Illinois Caverns has increased over the years since the cave was opened to visitors. Vandalism includes the killing, injuring, and/or removal of animals, insects, or any other living thing that is a part of the ecosystem of the cave. It also includes destruction or collection of stalactites, stalagmites, fossils, or any other natural materials within the cave. Scratching or writing with spray paint, lamp black, or anything else on the walls or formations within the cave is against state law and is strictly forbidden. Careless disposal of trash (for example, batteries and paper products) in the cave is also considered vandalism. Avoid touching stalactites and stalagmites. They are delicate and may break. The natural oils on your hands may halt their growth and development.



The First Waterfall (20 minutes)

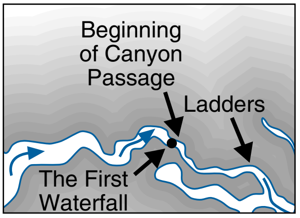
This small waterfall, which has a vertical drop of about 3 feet, illustrates how plunge pools form. The water pouring over the falls and into the pool carries sand and gravel during periods of high, fast-moving water. The impact and grinding of these materials on the cave floor can eventually abrade the stream bed into a smooth, concave basin called a ***plunge pool.*** Additional abrasion from the motion of rock particles trapped in the basin helps deepen the pool. Near the falls, you can also see another stream bed feature, a pothole, the bowl-shaped depression in the rock beside the bridge (fig. 53).

A small upper passage above the falls (fig. 54) extends from the wall where you approach the falls to the wall that is around the corner on your left as you cross the bridge. This upper passage is a remnant of a branch of the cave stream that was eventually abandoned—probably tens of thousands of years ago—in favor of the passage you walk through today. Flowstone formed at both ends of the upper passage; at the downstream end, the

Figure 53 Potholes are located immediately adjacent to the first waterfall and just left of the metal bridge. They were formed when stream gravels were spun by an eddy in an initially shallow depression in the rock. Continued spinning of gravels within the depression created this bowl-shaped feature. These excellent examples are found further on in the cave.

flowstone trapped and suspended a block of rock that fell from the ceiling. Short fragments of abandoned passages are common in Illinois Caverns, and others are encountered later as your tour continues.

Figure 54 An upper passage just before the first waterfall extends only to the other side of the waterfall. The upper passage was abandoned by the cave stream tens of thousands of years ago.



Canyon Passage (24 minutes)

The Canyon Passage begins at a noticeable narrowing of the cave just after the waterfall (fig. 55). At this point, you can no longer avoid walking in the stream water, which is cold (about 54°F) but not unbearable.

There is a series of relatively large stalactites in the Canyon Passage that you must duck beneath or go around (fig. 56). These features do not have matching stalagmites rising from the floor as seen in other parts of the cave. The calcium carbonate-rich water dripping from the stalactite lands in the stream and gets washed away before it has a chance to precipitate calcite and form a stalagmite. Without the stream, the stalactite would probably have met a stalagmite growing up from the floor, formed a column, and partially blocked the passage. For those stalactites that almost touch the stream, the stream water dissolves the bottom tip of the stalactite during flooding. The periodic rinsing of the leading edge of stalactites with

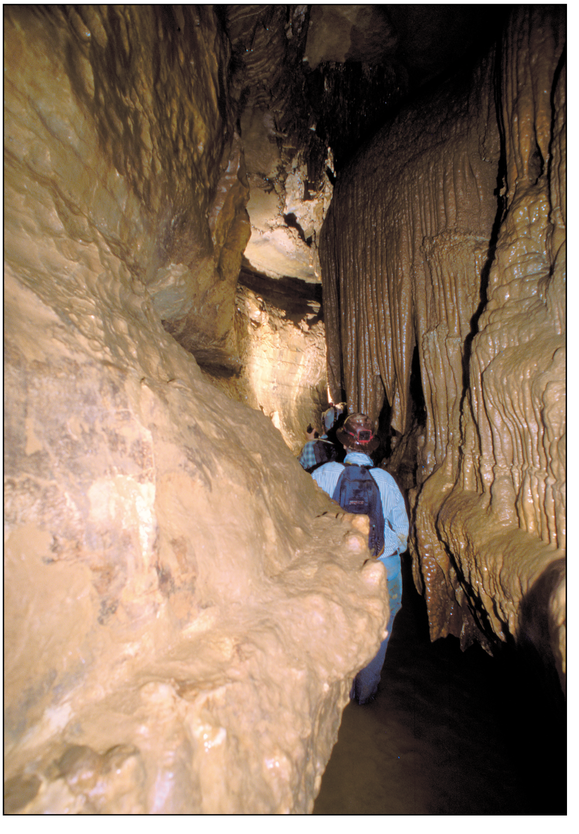


Figure 55 At the Canyon Passage, beginning just after the first waterfall, visitors must begin walking through the cave stream.

water during flooding dissolves calcite and probably keeps the stalactites from growing longer. As the cave stream erodes its bed, the stalactites will continue to grow downward.

Figure 56 You must squeeze between two large stalactites to continue on through the Canyon Passage. The stream water carries the dripping water away from the cave floor and prevents the formation of columns that would eventually block the passage.

Scallops along the Stream Bed

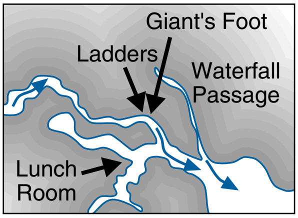
Many indentations can be seen on the floor and walls of the stream bed just downstream from the waterfall (as you descend the iron steps into the stream) and within the Canyon Passage (fig. 57). These indentations in the limestone—called scallops—in this cave measure about 2 inches in diameter. Scallops are asymmetrical cusps. The steepest part of the cusp is on the upstream side. Scallops are common where the stream flows across irregular rock faces on the stream walls and on the stream bed. Eddies form on the lee (sheltered) side of the irregularities, and the recirculating flow is responsible for dissolving the rock surface into smooth cusps. They are best observed when the water is low. The geometry and size of scallops indicate the direction and rate of water flow. The larger scallops are formed by slower-moving water, and the smaller scallops by faster-flowing water.

Figure 57 Scallops are dissolution features that form on the surface of rocks that line streams. The scallops look as if someone had taken an ice cream scoop and scooped out limestone. Small scallops (about 1 inch in diameter) indicate high-velocity flow, and large scallops (about 1 foot or more in diameter) indicate low-velocity flow.

Protocave

In some places, sinuous channels can be seen on the ceiling of the cave (fig. 58). These features are part of anastamosis tubes a fraction of an inch in diameter that developed into a larger conduit about 4 inches to 3 feet in diameter. These features look like the rivulets of water that flow down a glass windowpane of an automobile windshield during a light rain. The water commonly divides into several streams that snake across the glass in many directions but generally flow downhill. Groundwater flowing between limestone bedding planes toward a lower elevation at a rather gentle slope forms similar rivulets. These flow routes are preserved in the rock as dissolution continues to enlarge the rivulet pathways. The ceiling channel generally follows the trend of the bends and curves of the cave because the cave passage originated as a sinuous channel near the ceiling (fig. 17), and the flowing water has since dissolved and abraded its way downward through the solid limestone for the last 100,000 years or so.

Figure 58 Anastamoses in the ceiling of the Canyon Passage show how rivulets of groundwater, flowing along bedding planes, can dissolve small tributaries.

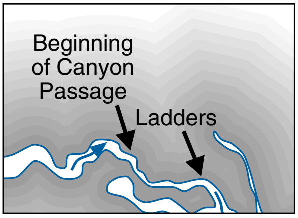


Ladders (40 minutes)

The cave's upper abandoned passages may provide a drier route for the explorer than the lower stream-filled passage. Near the end of the Canyon Passage, a dry upper passage is accessible by climbing a small steel-grid ladder lying against flowstone at a shallow angle. This upper passage is narrow and about 30 feet long and it ends at a 10-foot aluminum ladder that you must climb down to return to the stream bed. The ceiling of the upper passage is about 6 feet high and contains the upper half of the original conduit or protocave that grew to become Illinois Caverns. This route provides a view of what the cave may have been like in its early stages of development. Because of the ladder climbing involved, this location can be a bottleneck for a relatively large group, but traversing the lower passage involves getting very wet crawling through the cave stream.

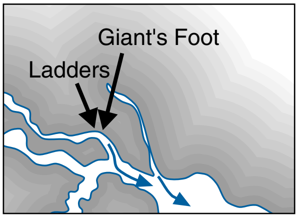
Figure 59 The scientist at the foot of the ladder momentarily holds his hat in his hands; his hard hat (but not his head!) was knocked off as he crossed between and under the stalagmites at this location.

Canyon Passage Stalactites



Descending the aluminum ladder from the upper passage, the cave explorer enters a forest of large stalactites that are still forming (fig. 60). Some of the stalactites have portions that have been broken off. If you look closely at the broken areas, you can see banding that represents thousands to tens of thousands of years of growth. Flowstone covers both walls of this part of the canyon, indicating an abundance of calcite-rich water seeping into the cave ceiling at this location.

Figure 60 The Canyon Passage just after the Ladders is filled with large, ornate stalactites and flowstone. The broken tips of some of the stalactites can reveal growth rings.

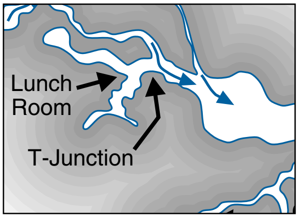


Giant's Foot (56 minutes)

The rock slab known as the Giant's Foot lies in the middle of the Canyon Passage (fig. 61). Clues to the formation of the Giant's Foot suggest that the almost 3,000-pound slab fell from the ceiling fairly recently: it is resting on stream gravels that cover the cave floor, and it still has sharp edges not yet smoothed by the dissolving action of flood-waters and abrasion by stream gravels. The shape of the side of the rock slab is similar to that where the wall meets the ceiling. The present ceiling has numerous anastamoses that were exposed when the slab fell. The continued development of the anastamoses likely separated the slab from the ceiling, causing it to fall. Another set of anastamoses can be found on the underside of the Giant's Foot rock slab.

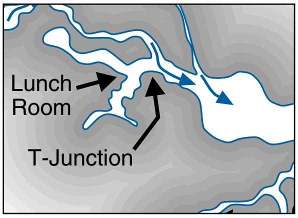
Figure 61 The Giant's Foot is a large slab of rock that fell from the ceiling of the cave near the end of the Canyon Passage.

T-Junction (60 minutes)



Emerging from the Canyon Passage is an intersection called the T-Junction. You may follow the passage to the right or left. To the right of the junction, climb up a small slope of fine sediment to a relatively dry upper passage known as the Lunch Room. This passage continues only for a short distance.

Figure 62 The T-Junction is the point where the Canyon Passage ends and the Main Passage begins. The T-Junction connects the Main Passage with the Lunch Room.



Lunch Room

Travel time to the Lunch Room from the T-Junction is a few minutes. The Lunch Room contains abundant stalactites, stalagmites, flowstone, rimstone pools (fig. 63), and a spectacular ***chimney*** (fig. 64). This upper passage is being undercut by a cave stream, which can be seen through holes in the floor at several locations along the route to the Lunch Room and beyond. Because the Lunch Room is relatively dry, but contains so many speleothems, this area must have received significantly more seepage of calcite-saturated water at some point in its history than is observed today.

Please note: There are several holes in the floor of this passage that are large enough to fall into. Use extreme caution.

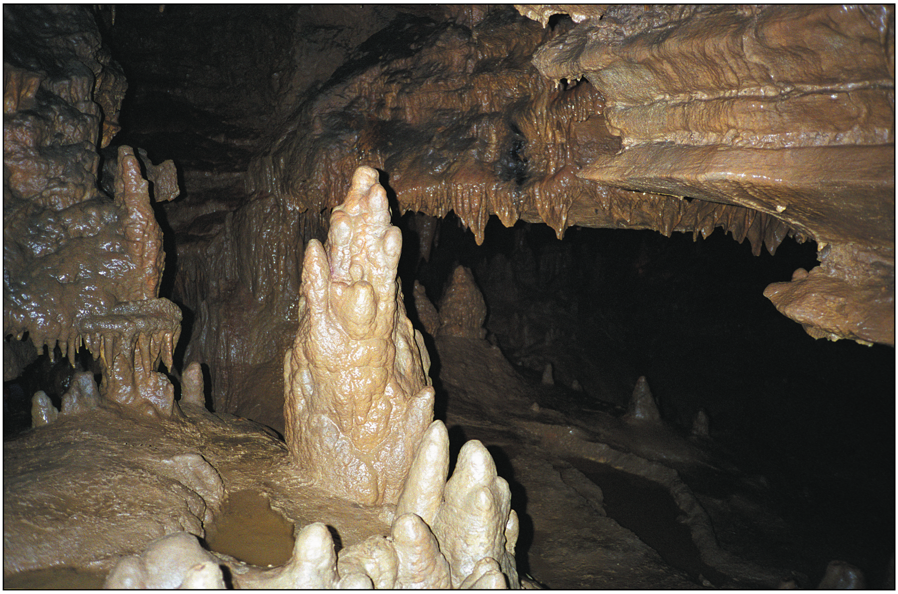
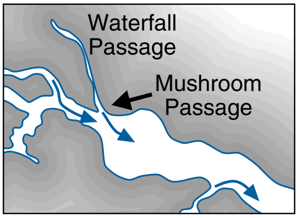


Figure 63 The Lunch Room contains some of the most interesting and beautiful speleothems (left) and chimneys (fig. 64) found in Illinois Caverns.

Figure 64 The well-formed chimney in the Lunch Room displays spectacular fluting and solution features that accentuate the bedding planes of the limestone bedrock.



Main Passage

At the T-Junction, turn left from the Lunch Room and walk straight ahead. You will follow the cave stream through a lengthy passage as it flows downstream. This passage is the main part of the cave and contains many formations. About 1 minute or so after leaving the T-Junction, you will come upon several large columns (fig. 65). The rock or sediment on which the columns rested has been dissolved or washed away by the cave stream. About 5 minutes farther along this passage is an even larger column that broke away from the ceiling but did not completely collapse. It now lies at about 20 degrees from its original vertical orientation and is tilted toward the stream (fig. 66). The fine-grained, stream-deposited sediment on which the column originally formed probably was undercut by the stream. The great weight of the column caused it to break from the ceiling and fall toward the stream. The flowstone deposited after the fall appears to have stabilized the column in its present position.

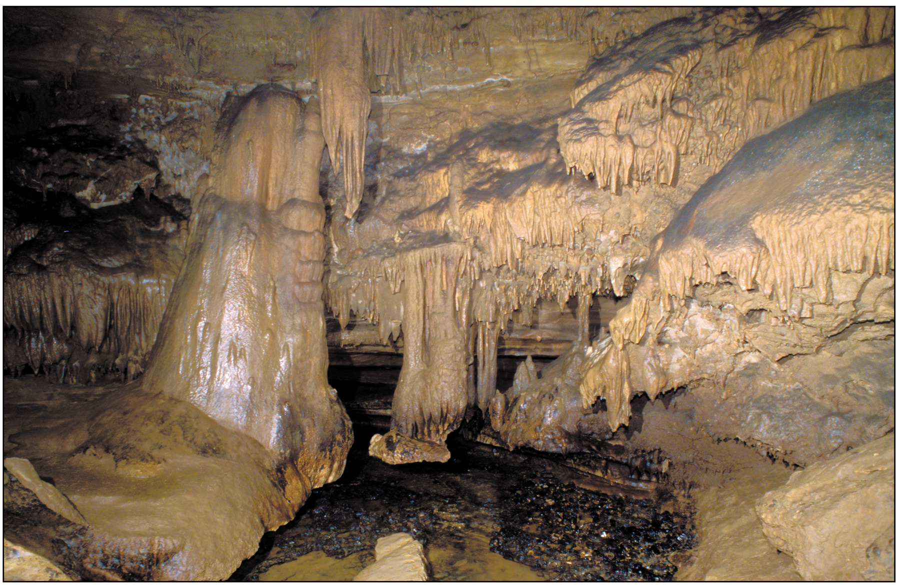
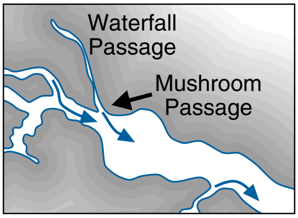


Figure 65 Two columns and stalactite-rich flowstone are located just left of the T-Junction. The column in the center of the photograph has been undercut by the stream and now hangs above it. The larger column on the left has also been undercut and now leans slightly toward the stream.

Figure 66 A large, partially collapsed column (left) is located a few minutes from the T-Junction. The collapsed column was stabilized with flowstone after its fall.



Mushroom Passage (72 minutes)

About 5 minutes farther along the cave passage, just after the waterfall passage, you encounter what looks like rock flowing from an upper passage (fig. 67). This feature most likely formed about 35,000 years ago when floodwaters filled Illinois Caverns with fine-grained sediments. Flowstone was deposited on top of this sediment and continued to form as the cave stream eventually removed all of the flood-related sediments.

As you duck beneath the flowstone hanging from the upper passage, notice the diverse nature and textures of the underside of the flowstone. Taking the low route (the upper passage is only about 30 feet in length), you soon enter the Mushroom Passage where mushroom-shaped flowstone formations are located immediately to the right of the passage. Flowstone in this area protrudes over and well above the cave floor and cave stream. The underside of the flowstone forms a horizontal surface that indicates where the surface of the stream was during some fairly prolonged period in the

Figure 67 Some upper passages were formed either on top of the cave stream when it was higher or on fine sediment that partially or totally filled Illinois Caverns sometime in the past. Additional growth of the flowstone after it spanned the cave width created the downward flowing effect. The even nature of the bottom of the flowstone suggests it hit the top of the stream when the water level was over 6 feet above its present level.

past. The mushrooms are thought to have formed during a particularly wet period of the late Wisconsin Episode of glaciation (about 25,000 to 10,000 years ago) when the water table and cave stream were higher and abundant flowstone was forming. The underside of the flowstone is flat and just met the water's surface. This overhanging "mushroom" formed because, as the flowstone precipitated, the stream water stopped its downward growth and began dissolving the base, causing the flowstone to grow out over the water (figs. 68 and 69). The underside of the flowstone reveals growth banding that extends outward from the wall. The mushrooms' growth stopped abruptly, probably as the stream level dropped because of drier conditions. If the mushrooms had continued to grow, there would be stalactites hanging from their edges similar to that of Rock Falls.

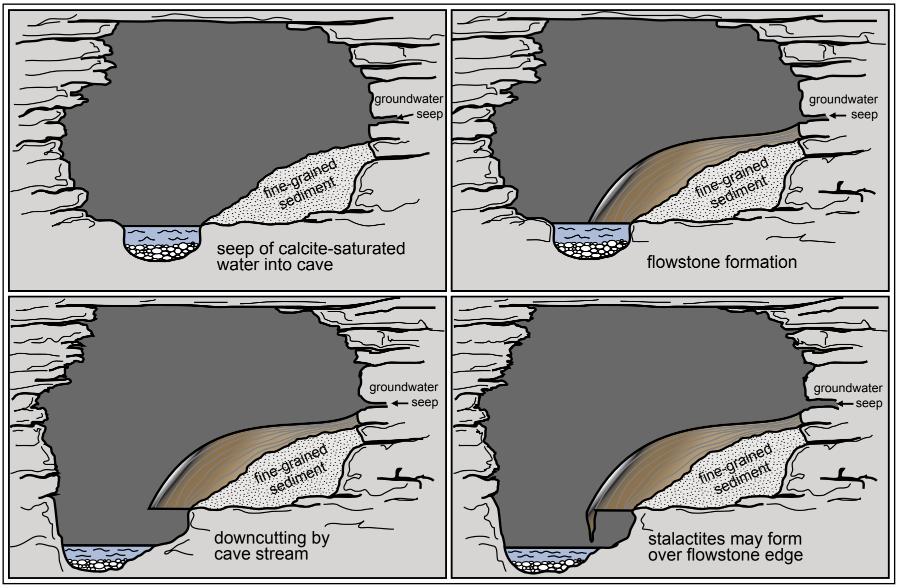
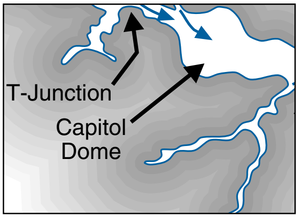


Figure 68 "Mushrooms" are formed when groundwater saturated with calcite seeps into the cave through the wall and flows down either a sloping rock surface or fine-grained sediment. The flowstone accumulates to form a layered rock mass that drapes over the material on which it grew. If the groundwater ends up flowing onto the surface of a cave stream, then it is washed away and doesn't deposit any more materials. The result is a flat-bottomed speleothem growing out over the surface of the stream. Years later, when the seepage has stopped and the stream is lower, the flowstone can resemble a mushroom.

Figure 69 Flowstone develops over the cave stream and forms a flat bottom that reveals growth rings moving outward from the wall (top). The "mushrooms" of the Mushroom Passage are remnants of this type of growth; however, the cave stream has cut deeper into the cave floor, leaving this flat-bottomed flowstone behind. These features can also be found growing out over the cave stream (bottom) and forming a flat-bottomed speleothem. The black streak on the flowstone (bottom) is deposited manganese oxide.

Capitol Dome (100 minutes)



Capitol Dome is a column (formerly a separate stalactite and stalagmite that grew together) that formed on a breakdown pile that is now, for the most part, covered with fine-grained, flood-deposited sediments and flowstone (fig. 70). The feature received its name because of its general shape, because of the striking whiteness of the flowstone, and because the stalactites on its front side resemble the columns around the base of the dome of the U.S. Capitol Building. The steps on the pathway up to the upper level and to the back side of the Capitol Dome were worn into the sediment by visitors over the last 100 years or so and reveal the limestone blocks that make up the breakdown pile (fig. 71). Large collapsed blocks of rock (formerly the ceiling) are exposed at the top of this upper passage.

Just behind the Capitol Dome is a large stalagmite that is actively forming (fig. 72). The small water-filled dimples on the surface (***microterracettes***) and the constantly dripping and flowing water are evidence of the stalagmite's rapid growth. Water rapidly drips onto this stalagmite throughout the year. The water is probably coming from a perched water table, that is,

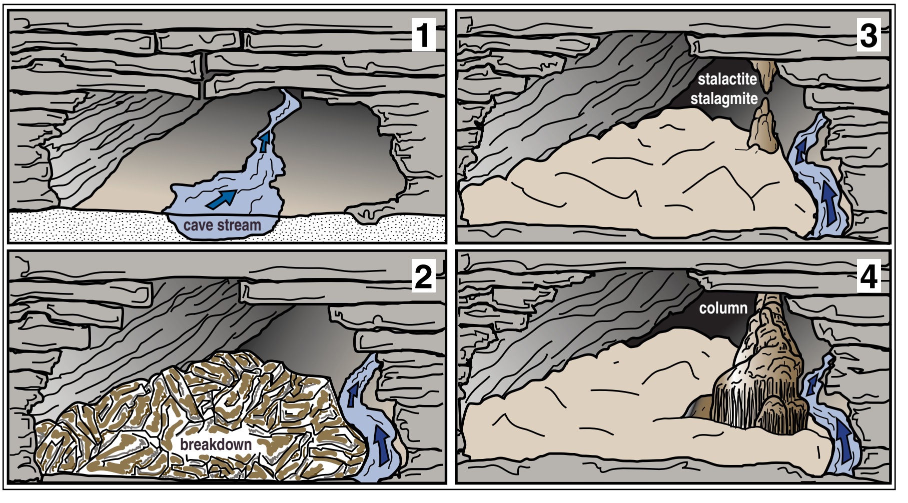
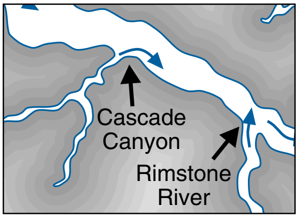


Figure 70 The area now occupied by Capitol Dome was a relatively wide stream passage until its roof collapsed and formed a breakdown pile. Subsequent flooding deposited fine-grained sediment on the pile. Stalactites and stalagmites began to form above and on the pile, perhaps as a result of the collapse and the opening of pathways for perched water to enter the cave ceiling. One stalactite and stalagmite eventually grew together and continued to grow over the edge of the breakdown pile to form flowstone that now resembles the dome of the U.S. Capitol.

Figure 71 Capitol Dome (left) is a large complex of stalactites, stalagmites, and flowstone that formed on top of a breakdown pile. Sediment covers most of the rock slabs (below), but the sediment has been worn down by visitors over many years.

an accumulation or reservoir of water within sediments that lie on top of the bedrock surfce and/or within the rocks themselves. Perched water can provide a constant supply of calcite-rich water for developing speleothems. Given time, this stalagmite will probably develop into a column similar to Capital Dome.

Figure 72 A large stalagmite located just behind Capitol Dome contains tiny pools called microterracettes on its top and sides. The microterracettes indicate rapid formation. The rate of water flowing onto the stalagmite varies with the seasons and rainfall events.



Cascade Canyon (140 minutes)

Originally referred to as Cascade Hall, Cascade Canyon is a narrow and interesting side passage that empties a steady flow of water into the main passage (fig. 73). The canyon-like passage consists of a series of rimstone pools on a large scale. Some are over 4.5 feet deep and 10 feet or more in length. The rimstone dams are large, some being several feet high. The effect is the muffled sound of numerous small waterfalls you hear as you make your way up the passage.

Adjacent to Cascade Canyon and just around the corner from this side passage are two ***seeps*** fed by ponds on the surface (fig. 74). The water from these seeps is low in mineral content and reflects seasonal temperatures. Periodic plugging of the seeps may reduce or stop the flow of water from these ponds from time to time.

Figure 73 The entrance to Cascade Canyon reveals a side passage with a long series of deep rimstone pools. The groundwater issuing from this passage probably has interacted with the bedrock limestone and become saturated with calcite prior to entering the cave passage. The flowing action of the water accelerates degassing of carbon dioxide and results in the precipitation of calcite dams.

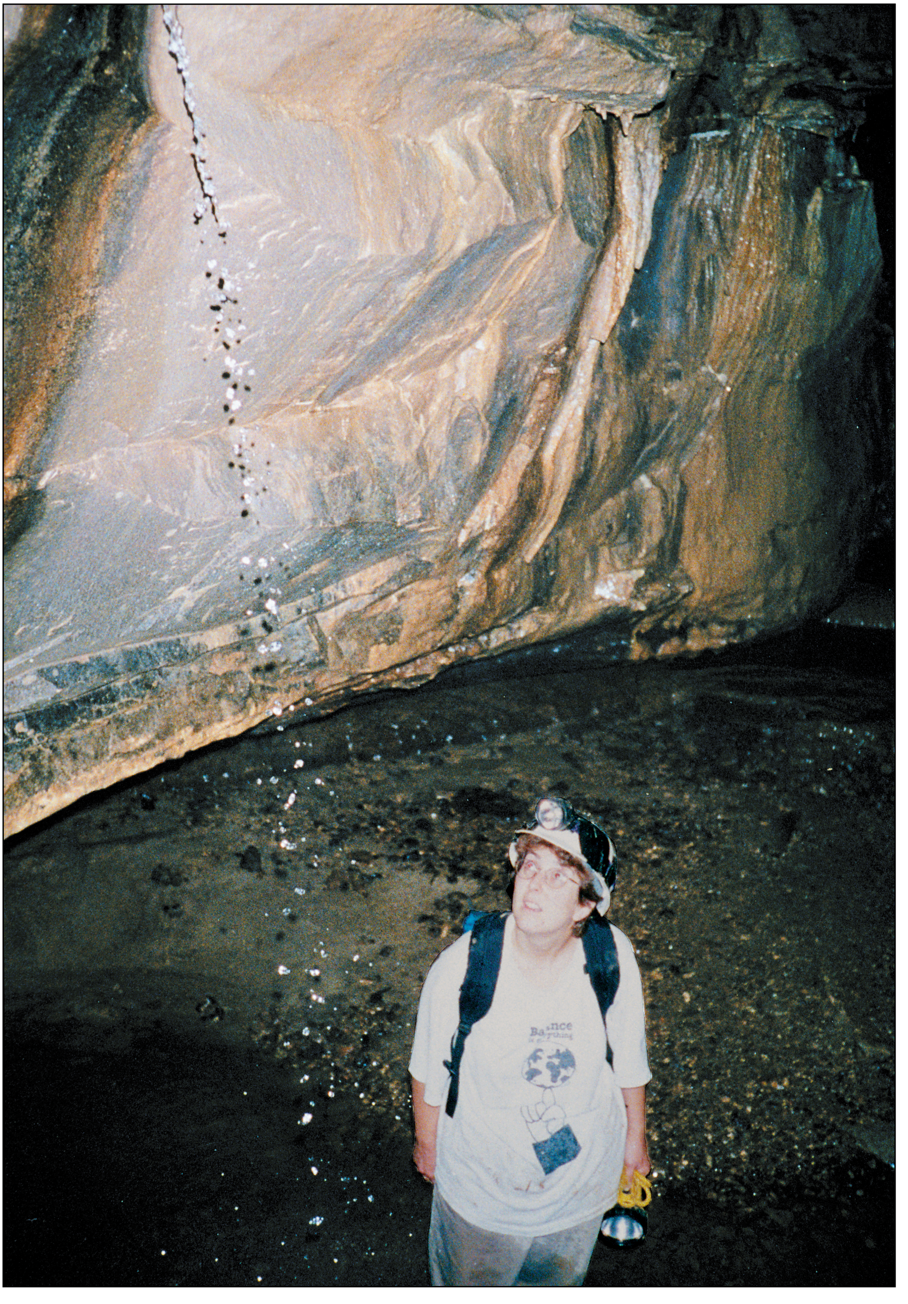
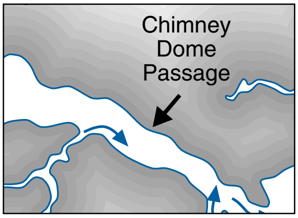


Figure 74 Water seeping from the bottom of a sinkhole pond on the surface has found its way into the cave near Cascade Canyon. Sinkhole ponds typically lose water to underlying crevices in bedrock. The warmer temperature and very low mineral content, relative to other seeps, indicates that this water is from a surface-water source and had a very rapid trip into the cave.



Chimney Dome Passage (160 minutes)

This passage contains several chimneys or vertical shafts in the ceiling (fig. 75). The chimneys are about 50 feet high or more and about 10 feet in diameter; they look like the inside of a chimney or silo. Chimneys form where surface water runoff and soil water flow into a vertical fracture so rapidly that the soil water doesn't have time to become saturated with the mineral calcite prior to entering the cave. As the surfaces of the fracture dissolve, the sides dissolve in a relatively small portion of the fracture. The more or less uniform flow down through a short segment of the fracture creates a tubular-shaped, vertical conduit to the cave. As this conduit widens, usually in all directions, the dissolution creates a chimney-like opening that can reach upward nearly to the overlying soil zone. Within chimneys, fluting and exaggeration of the limestone bedding are common (figs. 64 and 75).

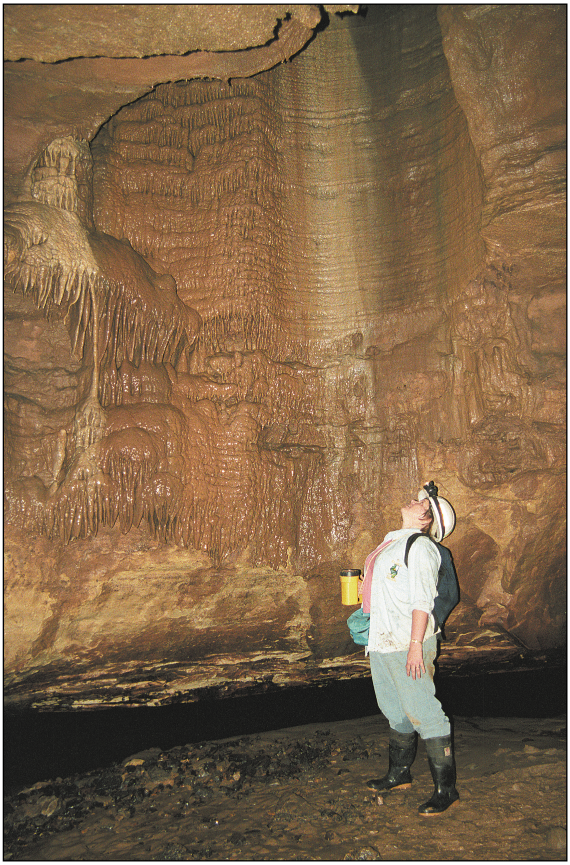
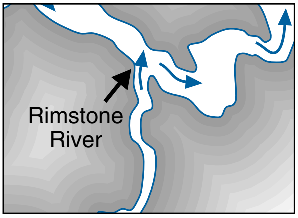


Figure 75 Chimneys extend up to near the top of bedrock in the Chimney Dome Passage.

At least one chimney has speleothems growing on one of its walls, which is unusual because the mineral-poor water seeping into a cave that forms chimneys should be capable only of dissolving rock, not of depositing calcite. It is likely that the flow path taken by the water that originally created the chimney has changed to a much more circuitous route, thereby saturating water with calcite prior to its entering the cave. These speleothems show clearly that water flow paths and the resultant water chemistry can change over time. Other chimneys may be found in the Lunch Room and near the entrance (fig. 64).

Figure 76 At the top of a large chimney you can see a stalactite forming, indicating a chemical change in the seep water from above.

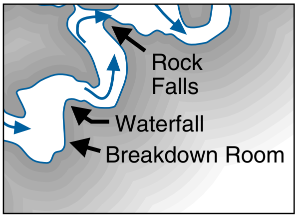


Rimstone River (180 minutes)

Rimstone River is a relatively large stream flowing from a side passage. The "river" has formed a series of rimstone pools similar to those in Cascade Canyon, but on an even larger scale. As in Cascade Canyon, some of the pools in Rimstone River are relatively deep. The same mechanisms that formed the rimstone pools of Cascade Canyon operate at Rimstone River. The ceiling of Rimstone River contains a well-preserved, relatively large protocave approximately 3 feet in diameter (fig. 77). The scoured, polished nature of the walls of the protocave suggest that groundwater, possibly carrying abundant sediments, flowed rapidly through this protocave.

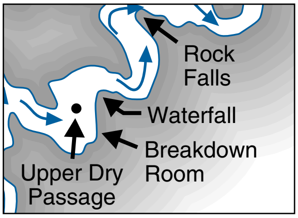
Figure 77 This view of the Rimstone River passage shows the protocave conduit in the ceiling and the roughly rectangular cross section of the passage.

Breakdown Room (200 minutes)



Breakdown forms when some part of the cave ceiling collapses (fig. 78); limestone slabs lie in a chaotic pile on the floor of the cave. This process is one way caves grow vertically. The Breakdown Room is one of the widest rooms in Illinois Caverns. The size of the room and the presence of breakdown are not coincidental. As the room widened, perhaps through meandering of the cave stream and sidewall collapse, the broad expanse of the ceiling may have resulted in the sagging of the limestone beds near the center. Because of the brittle and relatively thin beds of the limestone and the lack of support, limestone slabs containing one or more layers of limestone broke away from the ceiling and formed a breakdown pile. Assuming the cave continues to enlarge and develop, the slabs eventually will be dissolved by inflowing water or covered by sediment, and, thus, some of the evidence of how the Breakdown Room got to be so large may be destroyed.

Figure 78 Large slabs of limestone have fallen from the ceiling of the cave in the Breakdown Room. This type of collapse is most common in relatively wide rooms with long expanses of flat ceiling. Breakdown is one way the cave can grow vertically and form a more stable domed ceiling in the process.

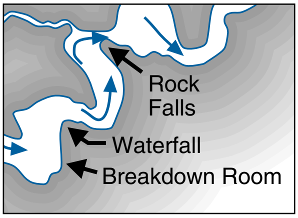


Upper Dry Passage (212 minutes)

Located just downstream of the Breakdown Room, the far end of the Upper Dry Passage is elevated and contains many dry rimstone pools. The upper passage is made of flowstone covered by sediment deposits. After climbing down at the other end of the passage and reaching the bottom, you need only to look behind you to see what appears to be a waterfall of stalactites suspended over the stream. Walking under the stalactites and in the stream reveals a large, bulbous stalactite and stalagmite forming near the edge of the stream (fig. 79). This stalagmite is forming quickly because of the rapid flow of water splashing across it, which accounts for the bulbous nature of the stalactite and stalagmite (fig. 80). Small rimstone pools also are found over the surface of the broad, fast-growing stalagmite. Based on studies in the area, at least some of the water that once flowed across the top of the upper passage has been diverted to form this speleothem.

Figure 79 A bulbous stalactite and stalagmite are growing very quickly as water, enriched in the mineral calcite, splashes down from above. The rapid flow rate and the splashing accelerate the loss of carbon dioxide and the growth rate of these speleothems.

Figure 80 From the Upper Dry Passage you can access the water creating the bulbous stalactite via a small hole leading to a crevice in the rock. Following it back a few feet, you come to a small rimstone river that finally plunges to create the stalactite below.

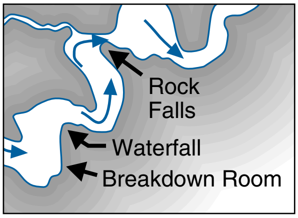


Waterfall (220 minutes)

A relatively large waterfall, measuring about 15 feet across and about 3 feet high (fig. 81), is located just downstream of the Upper Dry Passage. The waterfall formed on a chert layer that dissolves much more slowly than limestone. The chert, which is normally light to medium brown in this area, appears black because of a coating of manganese and iron oxides. The cave water flowing over the hard lip of chert, especially during flooding, gradually dissolves the underlying limestone, undercutting the chert. Eventually, the overhang becomes too large to support itself, and a part of the chert layer collapses. In this way, slowly but surely, the waterfall's position migrates upstream.

Figure 81 Waterfalls can form where chert (commonly known as flint) forms layers. The vertical drop of this waterfall is about 3 feet.

Rock Falls (280 minutes)



Rock Falls, a feature named by the authors, is an apron of flowstone that extends out over the cave stream and appears to have defied gravity during its development (fig. 82). The shape of the flowstone illustrates the changing conditions within the cave. The flowstone either built out onto fine sediment that once partially filled the cave or built over the cave stream when it was at a higher level. Unlike the Mushroom Passage, these speleothems remained active; water flowing over the flowstone drips down from the suspended platform and is forming the stalactites that now give it its cascading appearance. The wetness of the flowstone and occasional drips from the stalactites indicate that the feature is still growing (see Mushroom Passage, page 78). If the features in the Mushroom Passage had continued to grow after the cave stream was abruptly lowered, then the mushroom-like features would look like Rock Falls.

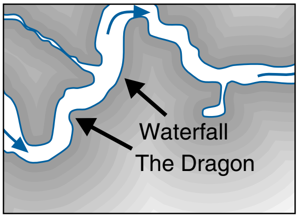
Figure 82 Rock Falls extends out over the cave stream, probably as a result of flowstone growing over the cave stream when it was at a higher level. The stalactites formed after the level of the cave stream dropped.

Potholes (320 minutes)

Potholes are bowl-shaped depressions that form within the layers of limestone. Cobbles or pebbles are deposited and then trapped in small depressions in the limestone stream bed where eddy currents from flowing water cause the pebbles to swirl in a circular motion. Over hundreds to thousands of years, the grinding action of the swirling rocks creates a pothole that can range from 4 to 12 inches in diameter and can be 4 to 6 inches deep (fig. 53). The limestone layer exposed in the stream bed at this location seems to be particularly susceptible to pothole formation (fig. 83). Here, the potholes are too numerous to count; most are about 10 inches in diameter, and many have cobbles lying in their centers. Where the limestone beds have been undercut by the cave stream, potholes have been eroded through the layer of limestone, forming a hole in the rock.

Figure 83 Potholes are abundant in some limestone beds within the cave. Although the rocks that created the potholes are not visible in this photograph, the action of the cave stream is apparent.

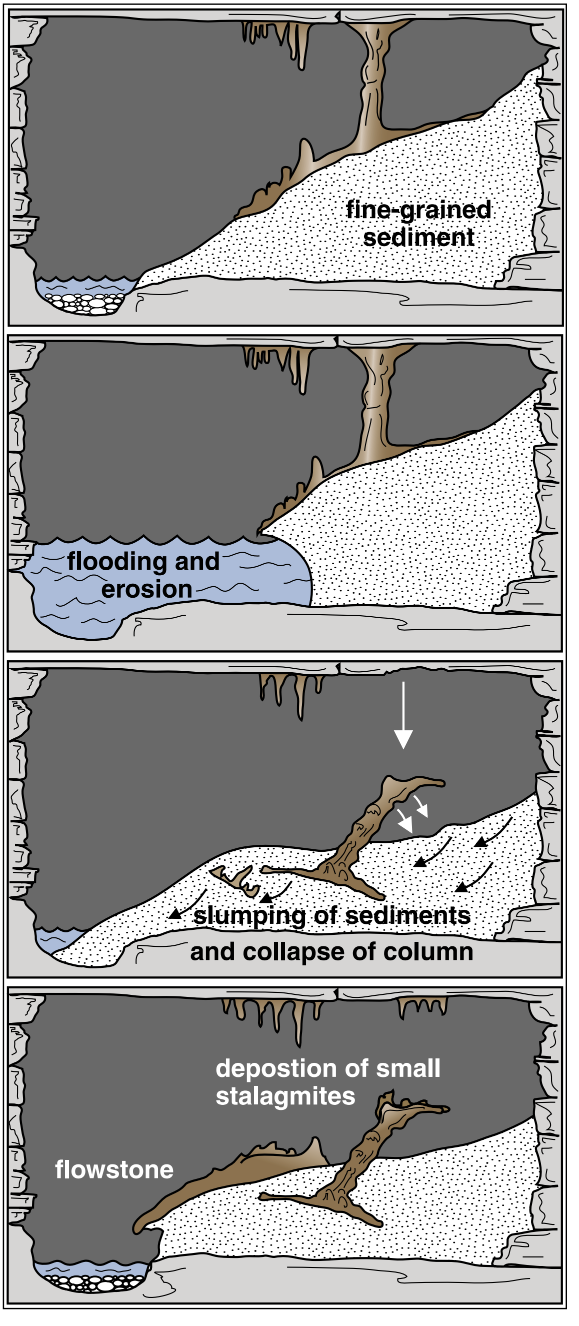
The Dragon (360 minutes)



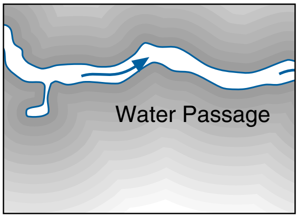
The Dragon is located to the right just before the Water Passage. The Dragon formed as a result of the partial collapse of a column, possibly caused by undercutting or slumping of the relatively soft sediment onto which it grew. The subsequent deposition of small stalagmites on the column's broken surface and the growth of small stalagmites on what is now its "back" give the feature its dragon-like appearance (figs. 84 and 85).

Figure 84 The Dragon is a fallen column or stalactite that appears to have been embedded in soft sediment. Subsequent formation of stalagmites on and adjacent to this speleothem help create the illusion of the silhouette of a dragon.

Figure 85 The Dragon is an example of a tilted speleothem that probably formed in a manner similar to the tilted speleothem found just before the Mushroom Passage. The head and neck of the dragon were a column that broke away from the ceiling. Undercutting caused the entire slope to slump toward the stream. As the sediment collapsed, the column was pulled along by the base. Water continued to drip on the broken column and formed small stalagmites, which now appear as spikes on the back and head of a dragon.



Water Passage and Beyond (368 minutes)



Farther downstream, a small waterfall marks the beginning of the Water Passage. Initially, this passage has deep water that eventually disappears at the Sand Crawl, a relatively low passage (about 2 feet high) mostly filled with sand.

Passage beyond the Sand Crawl is not permitted by the Illinois Department of Natural Resources. It is described as an unpleasant journey involving crawling through deep mud in an area known as "The Sewer." Here, at least for humans, the cave ends.

Dye Spring

Although the cave abruptly becomes too small for a human to enter, the water from the cave stream continues on, flowing in part through sediment-filled conduits and small open crevices. The water flowing through the cave eventually flows out onto the surface at Dye Spring, located on private land in a wooded area southeast of the entrance (fig. 86).

Figure 86 Dye Spring is one of the resurgence or discharge points for water flowing through Illinois Caverns. This relatively small spring flows from the base of a hill to form a small stream. The spring is located on private property about 2.5 miles southeast of the cave entrance.

The spring feeds a small tributary of Horse Creek that eventually flows to the Mississippi River. This discharge for Illinois Caverns was discovered by Father Paul Wightman in 1969 (fig. 10). Father Wightman was an active caver in the area and discovered, mapped, and traced the groundwater flow of some of the longest caves in the state to their discharge points using fluorescent dyes. At one point, Father Wightman's efforts turned a stream flowing past Tipton Church to a bright green color on Easter Sunday morning. It was a memorable sight for the parishioners.

ACKNOWLEDGMENTS

The preparation of this document was partially supported by a grant from the Illinois Department of Natural Resource's Conservation 2000 Program through the Monroe County Soil and Water Conservation District (SWCD). The authors thank Michelle Chausse and Jean Oettle of the SWCD for their assistance in the management of the grant. The authors thank the following people for their assistance in the development of this and companion documents: Armin Krueger for his assistance in our initial work on this document; Julie Kaiser for her early development of the ideas for educational materials; Chris Hespen, Site Interpreter at Illinois Caverns, for his assistance in the field and his review of the manuscript; Vic Hamer, Site Superintendent, for his assistance with site access and historic information; and Father Paul Wightman for his assistance with historic information. Also thanked are ISGS staff members for their assistance with preparation of figures and production: Joel M. Dexter for photography; Cheryl K. Nimz and Joel A. Steinfeldt for editing and production; and Jonathan H. Goodwin and Myrna M. Killey for their critical reviews and suggestions. Photographs were taken by S.V. Panno, Joel M. Dexter, M.R. Jeffords, and S. Taylor.

CREDITS

p. 12, fig. 12, modified from McKee and Crosby 1975 and Witke 1990.

p. 14, fig. 14, modified from Killey 1998.

p. 40–42, fig. 38, American kestrel, *Falco sparverius*; fig. 39, *Lampropeltis calligaster calligaster;* fig. 40, *Thamnophis proximus proximus;* fig. 41, *Argia fumipennis violacea* are courtesy of Michael R. Jeffords, Illinois Natural History Survey.

p. 45, fig. 43, *Gammarus acherondytes* photograph (top) from Steve Taylor, Illinois Natural History Survey.

SELECTED REFERENCES AND FURTHER READING

Aley, T., P. Moss, and C. Aley, 2000, Delineation of recharge areas for four biologically significant caves in Monroe and St. Clair Counties, Illinois, Report to the Illinois Nature Preserves Commission and the Monroe County Soil and Water Conservation District: Protem, Missouri, Ozark Underground Laboratory, 254 p.

Anonymous, 1883, Combined history of Randolph, Monroe, and Perry Counties, Illinois: Philadelphia, Pennsylvania, J.L. McDonough & Co., 510 p.

Appelo, C.A.J., and D. Postma, 1994, Geochemistry, groundwater and pollution: Rotterdam, A.A. Balkema, 536 p.

Ashley, D.C., and W.R. Elliott, 2000, Missouri cave life: Missouri Conservationist, p. 12–17.

Ballard, S.R., and V. Hamer, 1996, Post oak barrens restoration plan for Fogelpole Cave Nature Preserve and Illinois Caverns State Natural Area, Monroe County, Illinois: Springfield, Illinois, Illinois Department of Natural Resources, 20 p.

Bradley, R.S., 1999, Paleoclimatology: Reconstructing climates of the Quaternary: San Diego, California, Harcourt Academic Press, 613 p.

Brady, J.E., 1997, Settlement configuration and cosmology: The role of caves at Dos Pilas: American Anthropology, v. 99, p. 602–618.

Bretz, J.H., 1942, Vadose and phreatic features of limestone caverns: Journal of Geology, v. 50. p. 675–811.

Dorale, J.A., R.L. Edwards, E. Ito, and L.A. Gonzalez, 1998, Climate and vegetation history of the midcontinent from 75 to 25 ka: A speleothem record from Crevice Cave, Missouri, USA: Science, v. 2, p. 1871–1874.

Elliott, W.R., 1996, The evolution of cave gating: American Caves, p. 9–15.

Ford, D., and P. Williams, 1992, Karst geomorphology and hydrogeology: London, Chapman & Hall, 601 p.

Freeze, R.A., and J.A. Cherry, 1979, Groundwater: Englewood Cliffs, New Jersey, Prentice-Hall, Inc., 604 p.

Gillieson, D., 1996, Caves: Processes, development and management: Cambridge, Blackwell Publishers, 324 p.

Grimley, D.A., 2000, Quaternary geology of the St. Louis Metro East area, *in* R.D. Norby and Z. Lasemi, eds., Paleozoic and Quaternary geology of the St. Louis Metro East area of western Illinois, 63rd Annual Tri-State Geological Field Conference, October 6–8, 2000: Illinois State Geological Survey, p. 3–33.

Hem, J.D., 1985, Study and interpretation of the chemical characteristics of natural water: Reston, Virginia, U.S. Geological Survey, Water-Supply Paper 2254, 263 p.

Hickman, Jr., C.P., and L.S. Roberts, 1990, Biology of animals: Dubuque, Iowa, William C Brown, p. 560–561.

Hill, C., and P. Forti, 1997, Cave minerals of the world, 2nd ed.: Huntsville, Alabama, National Speleological Society, 463 p.

Hofmann, J.E., 1997, Bats and caves, *in* Guide to the geology of the Columbia and Waterloo Area, Monroe County, Illinois: Illinois State Geological Survey, Field Trip Guide 1997A, p. 69–71.

Illinois Department of Natural Resources, 1996, Illinois Caverns State Natural Area (brochure): Springfield, Illinois, 6 p.

Illinois Department of Public Health, 1994, Water well construction code 77: Springfield, Illinois, Illinois Adminstrative Code, Ch. I. 920, 42 p.

Jackson, J.A., ed., 1997, Glossary of geology, 4th ed.: Alexandria, Virginia, American Geological Institute, 769 p.

Jeffords, M.R., 1997, Living labyrinths, *in* Guide to the geology of the Columbia and Waterloo Area, Monroe County, Illinois: Illinois State Geological Survey, Field Trip Guide 1997A, p. 65–69.

Killey, M.M., 1998, Illinois' Ice Age legacy: Illinois State Geological Survey, GeoScience Education Series 14, 66 p.

Klein, H.R., ed., 1967, Arrowheads to aerojets, Historical Book Committee of the Monroe County Historical Society: Valmeyer, Illinois, Myron Roever Associates, 959 p.

Krajick, K., 2001, Cave biologists unearth buried treasure: Science, v. 293, p. 2378–2381.

Lasemi, Z., and R.D. Norby, 2000, Middle Mississippian carbonates in the St. Louis Metro East area: Stratigraphy and economic significance, *in* R.D. Norby and Z. Lasemi, eds., Paleozoic and Quaternary geology of the St. Louis Metro East area of western Illinois, 63rd Annual Tri-State Geological Field Conference, October 6–8, 2000: Illinois State Geological Survey, p. 1–18.

Lehr, J.H., T.E. Gass, W.A. Pettyjohn, and J. DeMarre, 1980, Domestic water treatment: New York, McGraw-Hill, p. 56–86.

Lineback, J.A., 1979, Quaternary deposits of Illinois (map): Illinois State Geological Survey, 1:500,000.

Madson, J., 1995, Where the sky began, land of the tallgrass prairie: Ames, Iowa, Iowa State University Press, p. 12–13.

McGimsey, M., 2000, Missouri bats: Missouri Conservationist, p. 18–23.

McKee, E.D., and E.J. Crosby, coordinators, 1975, Paleotectonic investigations of the Pennsylvanian System in the United States, Part 3—Plates: Reston, Virginia, U.S. Geological Survey, Professional Paper 853.

Mohr, C.E., and T.L. Polson, 1966, The life of the cave: New York, McGraw-Hill Book Co., 232 p.

Moore, G.W., 1952, Speleothem—A new cave term: National Speleological Society News, v. 10, no. 6, p. 2.

Palmer, A.N., 1981, A geological guide to Mammoth Cave National Park: Teaneck, New Jersey, Zephyrus Press, 196 p.

Palmer, A.N., 1986, Prediction of contaminant paths in karst aquifers, *in* Environmental Problems in Karst Terranes and Their Solutions Conference, Bowling Green, Kentucky: Dublin, Ohio, National Water Well Association, p. 32–53.

Palmer, A.N., 1991, Origin and morphology of limestone caves: Geological Society of America Bulletin, v. 103, p. 1–21.

Panno, S.V., 1996, Water quality in karst terrain: The Karst Window, v. 2, no. 2. p. 2–4.

Panno, S.V., B.B. Curry, H. Wang, K.C. Hackley, and C.-L. Liu, 2001a, Implications for climate change and speleogenesis in southern Illinois based on the age of redeposited glacial till in Fogelpole Cave (abs.): Boulder, Colorado, Geological Society of America, Program with Abstracts, Geological Society of America Annual Meeting, Boston, Massachusetts, November 5–9, 2001, v. 33, no. 6, p. A-24.

Panno, S.V., B.B. Curry, H. Wang, K.C. Hackley, C.-L. Liu, C. Lunstrom, and J. Zhou, 2004, Climate change in southern Illinois, USA, based on the age and δ^{13} of organic matter in cave sediments: Quaternary Research 61: 301–313.

Panno, S.V., K.C. Hackley, H.H. Hwang, and W.R. Kelly, 2001b, Determination of the sources of contamination in karst springs using isotopic and chemical indicators: Chemical Geology, v. 179, p. 113–128.

Panno, S.V., K.C. Hackley, W.R. Kelly, and H.H. Hwang, 1999, Sources of nitrate contamination in karst springs using isotopic, chemical, and bacterial indicators: Preliminary results, Proceedings of the Illinois Groundwater Consortium's Ninth Annual Conference, Research on Agricultural Chemicals in Illinois Groundwater, April 1, p. 91–103.

Panno, S.V., W.R. Kelly, C.P. Weibel, I.G. Krapac, and S.L. Sargent, 2003, Water quality and agrichemical loading of two large groundwater basins in southwestern Illinois: Illinois State Geological Survey, Environmental Geology 156, 36 p.

Panno, S.V., I.G. Krapac, C.P. Weibel, and J.D. Bade, 1996, Groundwater contamination in karst terrain of southwestern Illinois: Illinois State Geological Survey, Environmental Geology 151, 43 p.

Panno, S.V., E.C. Storment, C.P. Weibel, and I.G. Krapac, 1997b, Bacterial species isolated from groundwater from springs, caves and wells in southwestern Illinois' sinkhole plain and their potential sources: Proceedings of the Annual Environmental Laboratories Seminar, October 2–3, Springfield, Illinois, p. 1–4.

Panno, S.V., and C.P. Weibel, 1999, Karst landscapes of Illinois—Dissolving bedrock and collapsing soil: Illinois State Geological Survey, Geobit 7, 4 p.

Panno, S.V., and C.P. Weibel, 2000, Caves in Illinois: Our subterranean landscape: Illinois State Geological Survey, Geobit 11, 4 p.

Panno, S.V., C.P. Weibel, and I.G. Krapac, 1997c, Differences in groundwater contamination of a shallow karst aquifer in Illinois' sinkhole plain relative to sinkhole density (abs.): Boulder, Colorado, Geological Society of America, Program with Abstracts, Geological Society of America, Salt Lake City, UT, v. 29, no. 6, p. 8.

Panno, S.V., C.P. Weibel, and W.B. Li, 1997a, Karst regions of Illinois: Illinois State Geological Survey, Open File Series 1997-2, 42 p.

Piskin, K., and R.E. Bergstrom, 1975, Glacial drift in Illinois—Thickness and character: Illinois State Geological Survey, Circular 490, 35 p.

Quinlan, J.F., 1988, Protocol for reliable monitoring of groundwater quality in karst terranes: Proceedings from the International Association of Hydrologists 21st Congress, Guilin, China, p. 888–893.

Raven, P.H., R.F. Evert, and S.E. Eichhorn, 1992, Biology of plants: New York, Worth Publishers, p. 410–421.

Ren, M., Z. Liu, J. Jin, X. Deng, F. Wang, B. Peng, X. Wang, and Z. Wang, 1981, Evolution of limestone caves in relation to the life of early man at Zhoukoudian, Beijing: Scientia Sinica, v. 14, no. 6, p. 843–851.

Rother, H., and C. Rother, 1996, Lost caves of St. Louis: St. Louis, Missouri, Virginia Publishing Co., 143 p.

Schmidt, V.A., 1982, Magnetostratigraphy of clastic sediments from caves within the Mammoth Cave National Park, Kentucky: Science, v. 217, p. 827.

Shinn, E.A., 1983, Tidal flat environment, *in* P.A. Scholle, D.G. Bebout, and C.H. Moore, eds., Carbonate depositional environments: American Association of Petroleum Geologists, Memoir 33, p. 171–210.

Shirley, S., 1994, Restoring the tallgrass prairie: Iowa City, Iowa, University of Iowa Press, 330 p.

St. Louis Post-Dispatch, 1901, Mammoth Cave near St. Louis reveals many wonders: St. Louis Post-Dispatch, February 17, 1901, p. 1, 4.

Straus, L.G., 1997, Convenient cavities: Some human uses of caves and rockshelters, *in* C. Bonsall and C. Tolan-Smith, eds., The human use of caves, BAR International Series 667: Oxford, Hadrian Books Ltd., p. 1–8.

SWIMPAC, 1977, Development policies background data: Report, Southwestern Illinois Metropolitan and Regional Planning Commission, Carbondale, Illinois, 234 p.

Taylor, S.J., 1998, Some common animals found in Illinois Caverns: Champaign, Illinois, Illinois Natural History Survey.

Taylor, S.J., and D.W. Webb, 1998, The fragile fauna of Illinois Caves: The Illinois Steward, p. 2–6.

Taylor, S.J., D.W. Webb, and S.V. Panno, 2000, Spatial and temporal analysis of the bacterial fauna and water, sediment, and amphipod tissue chemistry within the range of *Gammarus acherondytes:* Champaign, Illinois, Illinois Natural History Survey, Technical Report 2000 (18), 115 p.

Tisdale, S.L., W.L. Nelson, J.D. Beaton, and J.L. Havlin, 1993, Soil fertility and fertilizers, 5^{th} ed.: New York, Macmillan Publishing Company, 634 p.

Treworgy, J.D., 1997, Mississippian rocks in Illinois: Illinois State Geological Survey, Geoscience Note, 8 p.

Tuttle, M.D., and D.A.R. Taylor, 1998, Bats and mines: Austin, Texas, Bats Conservation International, Inc., p. 20–25.

U.S. Environmental Protection Agency, 1991, National primary drinking water regulations, final rule: U.S. Federal Register, 40 CFR, Parts 141, 142, and 143; v. 56, no. 20, p. 3526–3594.

Weibel, C.P., and S.V. Panno, 1997, Karst terrains and carbonate rocks of Illinois: Illinois State Geological Survey, Illinois Map 8, 1:500,000.

Weller, S., and J.M. Weller, 1939, Preliminary geological maps of the pre-Pennsylvanian formations of southwestern Illinois: Illinois State Geological Survey, Report of Investigations 59, 15 p.

White, J., 1994, How the terms *savanna, barrens,* and *oak openings* were used in early Illinois, *in* Proceedings of the North American Conference on Barrens and Savannas: Normal, Illinois, Illinois State University: 407 p.

White, W.B., 1988, Geomorphology and hydrology of karst terrains: New York, Oxford University Press, 464 p.

White, W.B., 1997, Color of speleothems, *in* C. Hill and P. Forti, eds., Cave minerals of the world, 2^{nd} ed.: Huntsville, Alabama, National Speleological Society, p. 239–244.

Wightman, P., 1967, Monroe County's cellar, *in* H.R. Klein, ed., Arrowheads to aerojets: Valmeyer, Illinois, Myron Roever and Associates, p. 71–73.

Willman, H.B., and J.C. Frye, 1970, Pleistocene stratigraphy of Illinois: Illinois State Geological Survey, Bulletin 94, 204 p.

Witzke, B.J., 1990, Palaeoclimatic constraints for Palaeozoic palaeolatitudes of Laurentia and Euramerica, *in* W.S. McKerrow and C. R. Scotese, eds., Palaeozoic palaeogeography and biogeography: London, The Geological Society of London, Memoir no. 12, p. 57–73.

Yarbrough, R.E., 1974, The physiography of Metro East: Illinois Geographical Society Bulletin, v. 16, no. 1, p. 12–28.

GLOSSARY

anastamoses The serpentine channels worn into the cave ceiling that are the top half of a tube formed in the rock; the very small conduits that may be observed in a few places in the walls of a cave.

aquifer A water-saturated body of rock or sediment that will yield a usable quantity of water to a well or spring.

barrens A terrain of rolling hills and plains that supports the growth of isolated clusters of hardwood trees amid an expanse of prairie vegetation.

bedding plane In sedimentary rocks, the division that separates each successive layer or bed from the one above or below. The bedding plane commonly marks a visible change in the components, color, or other characteristics of the rock.

brachiopod A marine animal with two shells that first became abundant in Ordovician time.

bryozoan A tiny, commonly found colonial animal; the oldest fossils, generally stony skeletons of calcium carbonate, come from the Cambrian time.

calcite $CaCO_3$. A common rock-forming mineral of sedimentary rocks. Dissolved calcite is abundant in ocean water and is the main component of the shells or "skeletons" of clams and other bivalves, corals, and many microscopic organisms. Limestone and speleothems are made up predominantly of calcite, although speleothems can be composed of other minerals. *See also* limestone.

carbonate rock Rock made up of carbonate minerals, especially calcite ($CaCO_3$) and dolomite (Ca Mg $(CO_3)_2$).

chert Microcrystalline quartz crystals (SiO_2). Chert was used by local Native Americans to make arrowheads and other stone implements found in the area.

chimney A vertical shaft that may extend up beyond the normal level of the cave ceiling for 50 feet or more. A chimney forms as a result of acidic soil water seeping into the top of the bedrock and flowing down a fracture that leads to the roof of the cave, dissolving the limestone layer that forms the cave's roof.

conduit A relatively large pathway through bedrock that, as one or part of a series of conduits, allows water to flow from where it is recharged to where it discharges from a seep or a spring.

copepod A generally minute freshwater or marine crustacean of the subclass Copepoda.

degassing A process by which soil water forms speleothems. Degassing is initiated by a change in pressure (from higher to lower) as soil water enters a cave and rapid loss of dissolved carbon dioxide.

dissolution The act of dissolving a mineral or any soluble substance in a liquid or solvent such as water.

dolomite $CaMg(CO_3)_2$. Both a mineral and a rock type, dolomite is typically formed by the alteration of calcite by magnesium-rich groundwater, generally at somewhat elevated temperatures.

echinoderm A sea-bottom animal that has an external calcite skeleton and fivefold symmetry; starfish and sea urchins are modern examples.

echolocation The process used by bats to locate objects by reflecting sound waves off them.

electrical conductance A measure of a material's capacity to conduct electricity known also as specific conductance. Pure water does not conduct electricity; however, as the amount of dissolved minerals increases in water, so does the electrical conductance of the water. Thus, electrical conductance can be used as an indirect measure of the concentration of dissolved minerals in water.

evapotranspiration The combined processes of water loss through evaporation and transpiration by plants.

flowstone Smooth, sheet-like deposit of minerals (generally calcium carbonate) that forms in caves as water seeps into the cave and flows across surfaces, degassing carbon dioxide from the inflowing water and precipitating calcite on the surfaces.

foraminifera A marine or freshwater protozoa belonging to the Sarcodina subclass of the order Foraminifer.

fossils Imprints or mineralized remnants of organisms that lived thousands, millions, or even billions of years ago. Fossils found in the Illinois' sinkhole plain include corals and the shells of other marine animals in the Mississippian limestone and the bones and teeth of Pleistocene mammals in the glacial drift.

gastropod A mollusk (e.g., snails and clams) belonging to the class Gastropoda.

groundwater Water that is present below the water table in the interconnected pore spaces between particles of soil, sand and/or gravel and in open fractures and/or solution channels in bedrock. The water flowing through Illinois Caverns is, by definition, groundwater.

groundwater basin Similar to a surface watershed, but an underground area that is drained of rainfall and snowmelt by a surface stream such as the Illinois River. The boundary between two watersheds defines a location where water falling on one side of the boundary flows toward one river and water falling on the other side flows to another river. The groundwater basin differs only in that it flows underground, sometimes in a cave.

hard water Hardness is defined as 2.5 times the concentration of dissolved calcium in the water, plus 4.1 times the dissolved magnesium concentration, expressed in milligrams per liter of water. Water with a hardness value greater than 120 mg/L is considered to be "hard," and a value greater than 180 mg/L is considered to be "very hard."

iron *See* manganese and iron.

joint A relatively wide planar opening in bedrock that originated as an extensive crack in the rock that may be partially or totally filled with soil or, if open, may act as a conduit for flowing water.

karst A topography characterized by sinkholes, caves, springs, disrupted land drainage, and an underground drainage system, formed through the solution of a soluble bedrock such as limestone, gypsum, or salt. The term karst originally referred to a region in Slovenia near its border with Italy where this terrain is especially well developed.

manganese and iron Elements that combine with oxygen gas (O_2) to form oxide coatings on pebbles and rock faces within the cave and near springs in the area. Both metals are fairly easily dissolved in groundwater isolated from interaction with atmospheric oxygen.

microterracettes The small, water-filled dimples on the surface of flowstone and large stalagmites.

ostrocode An aquatic crustacean belonging to the subclass Ostracoda.

permeability The capacity of a sediment or rock for transmitting a fluid. Permeability is directly related to the number, size, and connectivity of its openings. Generally speaking, water can flow faster through more permeable material. *See also* porosity.

plan view Also called map view; what one sees when standing or flying directly over something.

plunge pool A deep pool of water at the base of a small waterfall along the cave stream. Plunge pools form as a result of scouring or grinding of the cave stream floor by rocks falling onto and being swirled about on the cave floor by the stream's current.

porosity The volume of voids or openings present in sediment or rock (expressed as a percentage of the total rock volume). Karst bedrock has two types of porosity: primary and secondary. Primary porosity is the percentage of void space in the solid rock material. Secondary porosity is the percentage of void space in the bedrock that formed after the bedrock became rock (for example, fractures, bedding planes, crevices, and caves).

pothole A bowl-sized, bowl-shaped depression in the cave floor that forms when a rock or rocks become trapped in a natural depression in the stream bed and are whirled in circles by small eddies formed by flowing water, gradually wearing a nearly cylindrical and round-bottomed depression into the surrounding rock.

protocave The precursor of the cave itself. In Illinois Caverns, it is the upper half of a conduit in the ceiling that was originally a 4-inch to 3-foot diameter conduit that formed (as a result of inflowing water dissolving the bedrock) between bedding planes. Water preferentially dissolved the conduit downward to form the cave.

rimstone pools Relatively small pools of water rimmed by dams made of calcium carbonate that precipitated from the mineral-laden cave water in the pool. Rimstone pools form when water that is saturated with calcite or other carbonate minerals flows over a naturally rough surface, degassing, and precipitates calcite to form a dam.

saseimensa *See* barrens.

scallops Dissolution features that form on the cave walls and beds of streams.

seeps Relatively small fractures where water flows into the cave at a relatively low but constant rate.

sink A feature such as a cave into which groundwater is drawn laterally from the surrounding rock (usually through crevices and along bedding planes), thus creating a constant seepage into the cave and maintaining the cave stream. A cave, in this case, can act as a horizontal well.

sinkhole A naturally occurring depression in the land surface, commonly cone- or bowl-shaped, formed as a result of the collapse of the underlying soil into a fissure; rarely, the collapse of a cave roof and the overlying soil.

sinkhole plain An area located in southwestern Illinois containing about 10,000 sinkholes in a three-county area (up to 230 sinkholes per square mile).

soluble Susceptible to being dissolved.

speleothem Derived from the Greek "spelaean" (cave) and "thema" (deposit); any mineral deposit within a cave that was precipitated from water, such as stalactites, stalagmites, columns, and flowstone.

spring The discharge point of caves and smaller conduit systems in karst terrain. The water flowing from a spring either forms or joins a surface stream that, in southwestern Illinois, eventually leads to the Mississippi River.

stalactite An icicle-like feature that grows downward from the ceiling of a cave when saturated groundwater enters the cave and precipitates calcite as a result of degassing of carbon dioxide.

stalagmite An icicle-like feature that grows upward from the floor by degassing or loss of carbon dioxide through agitation. The agitation is greatest at the top of the stalagmite where the water from the overhanging stalactite hits and splashes.

troglobite Organism that lives all of its life in the total darkness of a cave and is unable to survive on the surface.

troglophile Organism that can live either in caves or in suitable habitats on the surface.

trogloxene Organism that spends part of its life or life cycle in caves and must travel to the surface to complete its life cycle (for example, bats).

water table The surface that marks the transition from the zone of saturation to the overlying zone of aeration; that surface of a body of unconfined groundwater at which the pressure is equal to that of the atmosphere. In Illinois Caverns (and in most caves) the surface of the cave stream marks the top of the water table.

The Geoscience Outreach program of the Illinois State Geological Survey uses many channels to inform the public about the geology and mineral resources of the state and the results of the Survey's research projects. The Survey distributes nontechnical publications, offers sets of rock and mineral specimens to Illinois schools and educational groups, presents lectures and exhibits, responds to inquiries, conducts workshops for teachers, and leads field trips. The Survey's full-day field trips, conducted in widely separated areas of the state, offer teachers, students, and the general public the opportunity to learn about the geologic processes that shaped the land and formed the rocks and glacial deposits.

The Geoscience Outreach program is specifically designed to assist in the teaching of earth sciences and to help citizens understand how the research programs of the Illinois State Geological Survey help to protect the environment and strengthen the economy of Illinois.